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News Briefs

General Developments

Inquiries about News Briefs, where no contact person is identified, should be referred to the Managing Editor, Journal of Research, National Institute of Standards and Technology, Building 101, Room E215, Gaithersburg, MD 20899-2500; telephone: (301) 975-3577.

NIST DEVELOPS RANDOMNESS TESTS FOR RANDOM AND PSEUDORANDOM NUMBER GENERATORS USED IN CRYPTOGRAPHIC APPLICATIONS

NIST has developed a suite of 16 tests to check the randomness of binary sequences produced by random or pseudorandom number generators that may be used for many purposes, including cryptographic, modeling, and simulation applications. The tests focus on those applications where randomness is required for cryptographic purposes, such as the generation of keying material. The tests have been documented in NIST Special Publication (SP) 800-22, *A Statistical Test Suite for Random and Pseudorandom Number Generators for Cryptographic Applications*. The publication and the associated tests are intended for individuals who are responsible for the testing and evaluation of random and pseudorandom number generators, including (P)RNG developers and testers. SP 800-22 provides a high-level description and examples for each of the 16 tests, along with the mathematical background for each test. The statistical tests and SP 800-22 are available at http://csrc.nist.gov/rng/.

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EUROPEAN ACCEPTANCE OF NIST-RECOMMENDED CONFORMITY ASSESSMENT BODIES (CABs)

The European Commission has accepted NIST designations of 33 CABs for full operation under the Electromagnetic Compatibility (EMC) and Telecommunications Equipment annexes of the U.S.-European Union (EU) Mutual Recognition Agreement (MRA), culminating 2 years of effort. Formal signature of both parties and the formal recognition of the U.S. and EU Telecom and EMC CABs was expected prior to the U.S.-EU Summit in December 2000. The CABs of both parties may then begin testing or approving products within their scope of accreditation and designation.

The U.S.-EU MRA, signed on Dec. 3, 1998, facilitates trade by allowing manufacturers the opportunity to bring products to market in a more timely fashion. It covers multiple sectors, including equipment subject to mandatory telecommunications and EMC regulations. For telecommunications and EMC, the agreement allows CABs in the territory of one party to test and approve equipment subject to the mandatory regulations of the other party. After a 2 year transition period in the agreement to allow time for regulatory changes and confidence-building, NIST nominated and the EU has accepted, 23 U.S. EMC Competent Bodies and 10 U.S. Notified Bodies.

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FLAMMABILITY ASSESSMENT METHODOLOGY FOR MATTRESSES

NIST, with the sponsorship of the Sleep Products Safety Council, recently completed a study of the fire behavior of bed assemblies made up of a mattress, foundation, and bedclothes. The focus was on development and

application of a reproducible means to simulate the thermal impact that burning bedclothes materials impose on a mattress. Different sets of bedclothes were burned first on top of an inert mattress to obtain data on heat release rate, flame spread rates, and heat flux to nearby objects. A unique, infrared imaging technique was developed for characterizing the heat flux patterns imposed on the inert mattress surface. The results, in terms of peak heat flux, duration, and area, were used to develop a pair of propane burners that impose on the side and top of a mattress heat flux patterns mimicking those imposed at a typical fixed location by burning

bedclothes. These burners were applied to mattress designs typical of current residential mattresses and to designs potentially less flammable to permit a wide range of fire behaviors. All of the altered designs offered some modification in fire behavior but they differed strongly in overall effect, ranging from a delay in the time to reach an undiminished heat release rate peak to greatly reduced mattress involvement in the fire. The burners successfully predicted the behavior of most mattress designs and now provide the mattress industry with a means to discriminate quantitatively between the fire performance of different mattress designs.

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BREAKTHROUGH IN QUESTION-ANSWERING AT THE NINTH TEXT RETRIEVAL CONFERENCE (TREC-9)

At the NIST-hosted TREC-9, researchers experienced a breakthrough in text retrieval technology that could result in improved products on the Web. In the second running of the Question-Answering track, the goal was to retrieve text snippets rather than documents in response to a question. Over 500 questions drawn from donated query logs were used for testing. These real questions made the task noticeably more difficult than the TREC-8 task, but despite the increased difficulty, the best-performing system was able to extract a correct answer to the question more than 65 % of the time. This system, from Southern Methodist University in Dallas, Texas, demonstrated the power of integrating multiple natural language processing techniques with abductive reasoning to produce a final score almost twice that of the other 27 groups that participated in the testing. Based on past TREC experience, this type of breakthrough will lead to major changes in the techniques used by systems in next year's TREC and then to improved question-answering products on the Web.

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NEW INSIGHTS INTO WEAR-OUT MECHANISMS OF ULTRA-THIN SILICON DIOXIDE GATE DIELECTRICS

Researchers at NIST have recently completed several extensive experimental investigations of the mechanisms responsible for defect generation and breakdown of thin silicon dioxide films. The results confirm that breakdown is directly related to the current passing through the dielectric. The results also demonstrate that degradation and breakdown are not due to the trapping of hot holes that is commonly believed. Furthermore, a frequency dependence of dielectric lifetime for ultra-thin oxides is observed under bipolar pulsed stressing conditions for the first time. These results provide the fundamental understanding necessary to help resolve the correct physical model for thin gate oxide wear-out and breakdown. This understanding is necessary to develop standard reliability testing techniques crucial for estimating the lifetime of future generations of transistors and for estimating the ultimate thickness limit of silicon dioxide for CMOS technology. The results of this study were presented at the International Reliability Workshop in October 2000 and the Semiconductor Interface Specialists Conference in December 2000.

As the semiconductor industry continues to increase integrated circuit performance by decreasing the lateral dimensions of metal-oxide-semiconductor (MOS) devices, the thickness of the silicon dioxide gate dielectric, which is projected to continue to be in use over the next 5 years, must also be scaled downward. The thickness of the gate dielectric in state-of-the-art microprocessors is 2.0 nm to 2.5 nm and will continue to decrease over the next several years. Thin silicon dioxide dielectrics exhibit high tunneling current and the impact on device reliability is not well understood.

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FIGHTING FIRE WITH FIRE PRODUCTS

Vehicle fires represent approximately one-quarter of the total number of fires responded to by local fire services. For the years from 1989 to 1993, there was an annual average of 425 000 fires in vehicles per year and 32 000 fires in passenger road transport vehicles. Alth ugh fires represent only a small percentage of vehicle-related injuries, they account for a significant percentage of U.S. fire injuries. For example, of the 15 000 fire injuries in the United States in 1994, approximately 10 % were vehicle-related. In an effort to address this national problem, NIST researchers have been investigating the effectiveness of fire suppressants in simulated post-collision vehicle fires.

The effectiveness of a number of commercially available fire suppressants as well as several emerging suppressant types were investigated in both underbody and engine compartment fire scenarios. The experimental results showed that it is highly improbable that an on-board fire suppression system will be able to extinguish all possible engine compartment and underbody fires and many suppressant types were found to be impractical for post-collision engine compartment applications. Under certain conditions, however, fire suppression was feasible. NIST found that an emerging

fire suppression technology based on air bag technology was the most effective suppressant type tested in the full-scale engine compartment scenario. The device burns a solid propellant, rapidly discharging inert combustion products and salt particulates. Full-scale underbody suppression experiments in an uncrashed vehicle showed that suppression of a (333 mL volume) gasoline-fed pool fire was achievable when the fuel was located under the vehicle footprint under low-wind conditions. Preliminary results indicated that solid propellant generators may be effective under conditions of low to moderate winds, even for fires burning within approximately 1 m of the footprint of a vehicle, with the fuel puddle behind a tire.

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NIST HELPS DEMONSTRATE MOBILE-CODE CONTROL

On Dec. 6, 2000, researchers at NIST and a private company demonstrated a novel technique for predicting and controlling CPU use by mobile code in the Internet. Once developed further, this breakthrough might ultimately lead to significant improvements in the safety and efficiency of Internet applications, which increasingly use mobile code, such as applets, scripts, and dynamically linked libraries, to deliver new software to millions of users. Without understanding the CPU time required by dynamically downloaded software, computer operating systems cannot effectively manage system resources or control the execution of mobile code. Unfortunately, since mobile code can be downloaded and executed on a wide variety of computer systems with a vast range of capabilities, software developers cannot specify CPU requirements a priority.

While investigating this problem, NIST researchers designed and evaluated a novel technique that shows some promise. The new technique adapts CPU time allocation to account jointly for the needs of specific programs and the capabilities of various computer nodes. The researchers discovered that CPU time requirements do not depend solely on the processor speed of various computers, but rather on a complex array of hardware and software factors. As a result, they developed benchmarks to calibrate the performance of computer platforms with respect to the most significant factors, and then designed an application model that can be expressed in terms of those factors. Further, the researchers developed transformation algorithms to scale an application model between pairs of computers. By choosing one computer as a reference node, two simple transformations enable an application model to be understood by any computer within a network. Initial experiments, involving two different execution environments, four distinct applications, and five computer systems have been successful,

Researchers at the private company incorporated the NIST CPU usage prediction models into two demonstrations presented at a recent DARPA Active Networks workshop. The first demonstration compared the effectiveness of controlling CPU usage in network nodes using three different policies: fixed CPU time per packet, predicted CPU time scaled based on relative processor speeds, and predicted CPU time scaled based on the NIST models. The demonstration relayed packets, some containing erroneous code, from a source to a sink through two network nodes, one fast and one slow. Erroneously coded packets were designed to consume as much CPU time as possible, while normally coded packets simply performed the required processing and then moved on to the next node. The demonstration revealed that assigning fixed CPU time to each packet allowed erroneously coded packets to steal significant amounts of CPU time on fast nodes and caused slow nodes to prematurely terminate normally coded packets. After scaling CPU time usage predictions to account for relative processor speeds, the results improved; however, the NIST-developed models performed best.

In a second demonstration, the private company incorporated the NIST CPU usage prediction models into the Active Virtual Network Management Prediction (AVNMP) system, a technology that predicts future load in a network. AVNMP runs ahead in time of the real network, using network-traffic models to predict future network conditions. As real time passes various prediction points, AVNMP compares reality against prediction and, if necessary, rolls back and restarts the simulation to limit prediction error. Given a fixed goal for prediction error, AVNMP takes appropriate actions to achieve the goal. For example, higher inaccuracies in predictions lead AVNMP to make a greater number of rollbacks, resulting in a smaller look-ahead into the future. In the demonstration, AVNMP rollbacks were triggered by inaccuracies in either the predicted message load or CPU usage on each node. When predicting CPU usage based on a fixed allocation, AVNMP required as many as 12 rollbacks per prediction cycle to maintain the desired fidelity during 200 simulated seconds. In contrast, when using the NIST CPU usage model, AVNMP required a maximum of three rollbacks per prediction cycle.

While these initial results appear promising, more research remains before the ideas can be applied practically. Three issues in particular must be resolved. First, the new NIST technique assumes that all application behavior can be measured prior to injecting a model

into network nodes. Unfortunately, application behaviors often reflect conditions that cannot be known before a program reaches a node. For this reason, the application model must be enhanced to account for such node-dependent conditions. Second, the models consist of fine-grained histograms, which must be exercised with Monte Carlo simulations in order to predict CPU usage. As a result, specific application models can be large and can require substantial computation to produce predictions. To some degree the space-time properties of the model can be modulated; however, the prediction error also changes accordingly. The third issue to be resolved involves characterization of error bounds. Before taking operational decisions based on predictions from the model, a node must consider the possible range of prediction error. NIST researchers have yet to characterize the error properties of their model.

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INTEROPERABLE MPI STANDARD DEMONSTRATED

The first public demonstration of the Interoperable Message Passing Interface (IMPI) took place at the Supercomputing 2000 (SC'2000) Conference held in Dallas, TX, in November 2000. IMPI is a generalization of the Message Passing Interface (MPI), the de facto standard for writing parallel scientific applications in the message passing programming paradigm, now provided by all high-performance computer vendors. IMPI specifies a protocol for interoperability among vendor MPI implementations, thereby extending the environments in which parallel jobs can be run to heterogeneous clusters. NIST staff members served as facilitators for the development of the IMPI standard, convening meetings, editing the specifications document, and developing conformance tests.

The participants in the SC'2000 demonstration ran their own implementation of the IMPI protocols on their computing platforms, communicating with the other implementations in real time on the floor of the SC'2000 exhibit center. The IMPI protocols were designed by a steering committee of current implementors of MPI. These protocols handle the demanding task of maintaining interoperability among all IMPI implementations while allowing for the independent evolution of the collective communication algorithms. No changes to user MPI code are required to use IMPI.

The NIST IMPI conformance tester is a Web-based system that exercises all aspects of the IMPI protocol. Vendors test their IMPI implementation by connecting their MPI implementation to the NIST IMPI Web page at http://impi.nist.gov/IMPI/.

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NIST RESEARCHERS RELEASE PUBLIC-DOMAIN DYNAMIC SOURCE ROUTING MODEL

In December 2000, at a meeting of the Internet Engineering Task Force (IETF), NIST researchers announced the availability of a validated, public domain OPNET model for the dynamic source routing (DSR) protocol, proposed as one of several candidates for routing in mobile ad hoc networks (MANETs). This model was developed as part of a collaborative project with DARPA. DARPA asked NIST to evaluate the military suitability of the MANET routing protocols being developed in the IETF. MANETs aim to provide routing in networks consisting entirely of mobile nodes, that is, networks without any fixed infrastructure.

Given a set of military requirements for routing in MANETs, NIST researchers developed criteria for evaluating MANETs. Many of the criteria relate to performance against relevant topologies and mobility scenarios. To compare candidate protocols fairly and accurately requires the existence of complete and validated protocol models. The DSR model released by NIST represents a first step to satisfy this need. NIST has released the DSR model publicly for use by companies, research laboratories, and other groups that wish to independently validate the model. The Web site is http://w3.antd.nist.gov/wctg.

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NIST DEVELOPS PHOTOMETRIC AND COLORIMETRIC STANDARDS FOR LEDS

NIST has started a new project to investigate and develop measurement methods and standards for photometry and colorimetry of light-emitting diodes (LEDs). Since high-intensity blue LEDs have recently become available, the application of LEDs is expanding rapidly in a wide variety of areas, including color displays, traffic and aviation signals, and signs. Accurate specifications of LED characteristics are therefore becoming increasingly important; however, large discrepancies in photometric measurements of LEDs (as much as 50 %) are being reported by manufacturers and users. In order to improve the situation, NIST has investigated the technical problems and is developing standard LEDs and recommended measurement methods for luminous intensity, total luminous flux, and

color (chromaticity and dominant wavelength). The NIST work is linked to the standardization efforts by CIE (Commission Internationale de l'Éclairage) committees TC2-45,−46; NIST intends to have available LED calibrations and standards in 3 years.
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NIST PROVIDES INSIGHT INTO MAGNETIC COUPLING THROUGH ANTIFERROMAGNETS

The study of the magnetic coupling between two ferromagnetic films separated by a non-ferromagnetic metallic spacer has been an extremely active and fruitful area of research over the last decade. The interlayer exchange coupling that causes the magnetization of the two ferromagnetic layers to be parallel or antiparallel to each other, depending on the thickness of the spacer, is now well understood when the spacer is a diamagnetic or paramagnetic metal. However, when the spacer layer is an antiferromagnet, such as manganese (Mn), the observed coupling is non-collinear.

In a paper soon to appear in the *Journal of Magnetism and Magnetic Materials,* researchers at NIST report scanning tunneling microscopy (STM) measurements of the growth of Mn on nearly perfect iron (Fe) single-crystal whisker surfaces to determine the thickness distribution of the Mn layer for particular growth conditions. The coupling angles measured for Fe/Mn/Fe(001) tri-layers, using scanning electron microscopy with polarization analysis (SEMPA), were in approximate agreement with the predictions of the so-called torsion model, developed to describe the more complicated interlayer coupling when exchange coupling within the antiferromagnetic spacer is important. STM measurements of the lateral scale of the Mn thickness distribution provide insight into ways to go beyond the torsion model to obtain a better explanation of the SEMPA results.
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NIST GRANTED PATENT FOR A COMPACT COMPRESSOR FOR POLARIZED ^{3}He GAS

By using optical methods, it is possible to align the magnetic moments of 3He nuclei with an applied magnetic field producing "polarized ^{3}He gas." Since its first production about 40 years ago, polarized ^{3}He gas has been employed for many applications such as low temperature physics, studies of nucleon structure, and, more recently, for neutron spin filters and imaging of the human lung. Work on the latter two applications has been pursued by NIST scientists, and has resulted in a patent entitled "Method and apparatus for the compression of a polarized gas" being recently issued to NIST.

Magnetic resonance imaging (MRI), which traditionally relies on the signal derived from the small equilibrium polarization of protons in water in a strong magnetic field, can be more effectively performed for lungs by using the large non-equilibrium polarization produced by optical pumping of ^{3}He gas. To produce the polarized gas, two optical pumping methods are being employed at NISTspin—exchange and metastability-exchange. The latter method can rapidly produce highly polarized gas but the process is best performed at low pressures of only a few mbar. For the intended applications, pressures on the order of 1 bar are required, necessitating compression of the gas with as little loss of polarization as possible. Accordingly, NIST researchers modified a commercial diaphragm pump and tested it for use with polarized ^{3}He gas. The loss of polarization was found to be acceptable, and can be minimized by increasing the flow rate through the compressor. To maximize the achievable polarization at high flow rates, a new scheme to optimize the efficiency of the optical pumping is being employed. The NIST compressor can produce values of ^{3}He polarization as high as 50 %, which is competitive for application to neutron spin filters and polarized gas MRI.
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SUPERCOOLING AND SUPERHEATING OF VORTEX MATTER

The behavior of quantized flux lines in type-II superconductors is of critical importance in a variety of high-current applications anticipated for "high temperature" superconductors, such as magnets for medical imaging and power transmission cables. These vortex systems also provide a prototypical system for the study of fundamental problems in phase transitions and melting phenomena. Unfortunately, vortex structures have been difficult to investigate in detail in the cuprate materials because of the intrinsically short superconducting length scales and because of materials quality problems. A current subject of wide interest concerns the possibility of a solid-liquid transition of vortex matter and its relation to the dramatic transport anomaly in superconductors known as the peak effect, in which the critical current exhibits a maximum rather than decreasing monotonically with increasing temperature. Researchers at Brown University and the NIST Center for Neutron Research have now carried out small angle neutron scattering measurements combined with in-situ ac magnetic measurements, on a high-quality niobium crystal where these experimental

difficulties are averted. They report the first structural evidence for a first-order vortex solid-liquid transition associated with the peak effect. In particular, superheating of the vortex solid and supercooling of the vortex liquid have been observed directly for the first time. This is an important result for assessing future technological applications, since there is a definite limit, by virtue of being a first-order transition, to which the materials properties can be tailored to achieve the highest critical currents. These results also open up the possibility to experimentally test the fundamental theoretical ideas of melting in bulk solids. For example, in conventional solids surface melting masks any superheating effects, while a superheated vortex lattice is stable for hours, but can be melted by applying a small perturbing ac magnetic field.
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PINNING MAGNETIZATION BY A SPECIAL THIN-FILM DEPOSITION TECHNIQUE

When materials are deposited onto substrates to make thin films, the usual goal is to produce a smooth deposit. However, recent work at NIST has shown that rough deposits can have some special advantages. In particular, when the incoming flux of atoms strikes the substrate at an oblique angle, a deposit is formed with a strongly textured surface consisting of parallel ridges and valleys. This structure has some special advantages for the fabrication of magnetic thin-film devices.

In the NIST work, it was found that a thin layer of tantalum, obliquely deposited, has a textured roughness that can have a strong effect on a magnetic layer deposited on top of it. The textured surface pins the magnetization direction in the magnetic material, producing a magnetic anisotropy. Such pinning of the magnetic direction is needed for the functioning of a special structure known as a spin valve, which is used in modern read heads of computer hard disks. The pinning is strong enough to prevent reversal of the magnetization direction of the magnetic film, and the pinning remains strong at the elevated temperatures that may be encountered during use.

The anisotropy produced by obliquely deposited tantalum thin films has a number of desirable properties: it is strong, it is uniform, and it has good thermal stability. In addition, the system has good corrosion resistance and chemical compatibility. These properties are advantageous, as the increased demand for sensitivity in read heads has led to higher current densities and hotter operating temperatures, and as read heads become smaller to accommodate narrower recorded tracks.
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ADVANCES IN PROCESS VISUALIZATION REVEALS NOVEL POLYMER STRUCTURE

Scientists from NIST have utilized in situ visualization technology to discover novel structures formed during processing of polymer blends. The observations, which will appear in *Physical Review Letters,* are the consequence of new measurement tools developed for elucidating the structure of polymer blends during processing. The novel structure results when the dimension of a manufactured part approaches the size of one of the components in an incompatible mixture of polymers. Under such conditions, the NIST measurements show that there is a massive reorganization of the structure of the dispersed polymer droplets. In a four-stage process, tens of thousands of the droplets join together to form extremely large strings. Instead of micrometer-sized droplets typical of polymer blending, these strings can be 10 cm in length, and have been observed to wrap around the processing flow. Once the strings form, they are extremely stable; in fact, it is hard to get rid of them.

Most engineering plastics are polymer blends. Polymer blending technologies are well developed for the case where the final part, such as a car bumper, is much larger than the size of the dispersed polymer droplet, typically 1 micrometer. The new observations suggest the need for alternative blending strategies when the size of the part becomes comparable to the size of the droplets. In addition, the string-like structure may lead to new applications, for example, conductive plastic wires, if the string component was a conductive polymer and the matrix was an insulator with good mechanical properties. If the string component formed a reinforcing fiber, one could have ultra-thin composite materials of high one-dimensional strength. Likewise dissolving out the string component from a biocompatible polymer could provide oriented pores for cell growth for tissue engineering.
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NIST HOSTS METADATA COMMITTEES

NIST recently hosted the meeting of two organizations with a focus on metadata descriptions and registries. The ANSI NCITS L8 Metadata Committee had a Special Interest Group and Plenary meeting to discuss progress in standardizing descriptions for data elements and other forms of metadata. Metadata is the data that defines and documents the data found in databases,

e-commerce messages, XML tags, and other forms of information exchanged among information technology systems. NCITS L8 is the Technical Advisory Group (national liaison) for ISO/IEC JTC 1/SC 32 WG2, also called Metadata. The major focus of both standards committees is the development of ISO/IEC 11179, *Metadata Registries* (MDR), and associated Technical Reports. An allied group, the Metadata Registry Implementers Coalition (MDRIC), also met. The MDRIC is an organization for information and tool designers who are building metadata registries based on the ISO/IEC 11179 standard.

NCITS L8 and MDRIC meet regularly at NIST. The focus of this meeting was the relationship between MDR-based registries and XML. Linking these two standards areas will promote interoperability and help ensure that people and organizations can make the best use of the resources available on the Web.

NIST is planning a 2 day event in September 2001 that will focus on MDR, XML, and related issues. For more information, see http://xw2k.sdct.itl.nist.gov/l8/.
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NIST CO-SPONSORS LARGE-SCALE NETWORK RESEARCH PLANNING WORKSHOP

In March 2001, leading researchers in the field of large-scale networking converged on Washington, DC, to help federal government agencies plan research initiatives for the next 5 years. NIST co-sponsored this workshop with the National Science Foundation (NSF), the Defense Advanced Research Projects Agency (DARPA), the Department of Energy (DoE), and the National Aeronautics and Space Administration (NASA).

Recommendations from this workshop will help shape key research issues that warrant government investment in the field of large-scale networking, a field in which past government investments over two decades have led to dynamic, explosive economic growth during the 1990s. The workshop was essential to help government agencies distinguish important research that industry will not undertake from research that industry will conduct. NIST provided key perspectives on these issues, which helped an interagency strategic planning group develop initial ideas to stimulate discussion at the upcoming workshop. Some of the initial ideas suggest that government agencies should fund networking research in the following areas: technology for agile, optical transport networks, techniques for shared use of scarce public wireless spectrum, automated device and service discovery and configuration, approaches to improve security and privacy in networks, autonomous network prediction and control, and theories for understanding global-scale information infrastructures.
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NIST HOSTS TOPIC DETECTION AND TRACKING (TDT) WORKSHOP ON TEXT ORGANIZATION

NIST hosted the third annual TDT Evaluation Workshop in November 2000. The workshop involved 30 academic and corporate researchers who participated in the NIST-administered TDT evaluation that occurred during the fall of 2000. The workshop followed the NIST Text Retrieval Conference (TREC), a related conference in the text retrieval research field, also hosted by the division.

The TDT program develops technologies that search, organize, and structure news-oriented textual materials from a variety of broadcast news media in both the English and Mandarin languages. The research-driven program uses controlled laboratory simulations of hypothetical systems to test the efficacy of potential technologies to access the continuously flowing information that is available from news-producing entities.

In earlier studies reported at last years TDT meeting, research showed that it was possible to track and organize events in news data even though the data was multilingual. The TV and radio broadcasts were transcribed using automatic speech recognition, and the Mandarin text was converted to English using COTS Mandarin-to-English software.

The focus of TDT changed in 2000 to the development of core techniques that organize news data. A second shift was to bring more of the real world into the evaluation by requiring TDT systems to operate on broadcast news audio data that has been transcribed, translated, and segmented into stories without human intervention. The Web site is http://www.nist.gov/TDT.
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NIST HOSTS NCITS STANDARDS COMMITTEE ON INFORMATION TECHNOLOGY (IT) ACCOMMODATION

NIST hosted a December meeting of the V2 Technical Committee in the National Committee for Information Technology Standards (NCITS), which is developing standards for IT accommodation for people with disabilities. NCITS develops national standards and its technical experts participate on behalf of the United States in the international standards activities of

ISO/IEC JTC 1 in Information Technology. The new NCITS committee will develop standards for the use of IT to support people with disabilities, including the development of protocols and specifications to support the implementation of intelligent, self-adjusting interfaces between accommodation devices and the human-computer interfaces (i.e., the keyboard, mouse, and display ports) and criteria and methods for the development of "best practice" guidelines.

At the meeting, the committee began identifying the scope and requirements for the first standard for an Alternative Interface Access Protocol (AIAP) communication protocol, which will complement and build on industry activity in home networking, wireless networking, and metadata registries for discovery and interoperation of intelligent devices. The AIAP will provide for access to a local system (intelligent device) or to one or more systems (intelligent devices) located on a network. AIAP may optionally be used to convey information about user interface system functionality, user preferences, and capabilities between a user interface system and another system with which the user intends to interact, so that alternative interfaces can be accommodated or constructed to provide fundamental access to computing services and information regardless of any limitation of the user.

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NIST HOSTS NINTH TEXT RETRIEVAL WORKSHOP (TREC-9)

NIST hosted the ninth workshop in the Text Retrieval Conference (TREC) series at NIST in Gaithersburg in November 2000. Seventy groups representing 17 countries participated in the workshop to discuss the results of a yearlong cycle of testing that was conducted by NIST.

In addition to the breakthrough in question-answer technology, a second emphasis in this years TREC was an examination of the infrastructure required to evaluate Web search engines. The Web differs from other data collections used in TREC in a variety of ways: size; variety of subject matter, media types, languages, and presentation styles; lack of specific editorial control; explicit links among documents; frequent changes to documents; and generated content. Any of these differences may impact retrieval effectiveness, and the challenge facing the retrieval community is building appropriate test suites that can isolate the effects of these different factors. The Web site is http://trec.nist.gov.

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NIST SPONSORS INDUSTRY USABILITY REPORTING WORKSHOP

With industry participation, NIST developed a Common Industry Format (CIF) for Usability Test Reports to provide a means for usability engineers to report results of their usability testing. In November 2000, NIST sponsored the 4th Industry Usability Reporting (IUSR) Workshop to further the progress in reporting usability. The NIST IUSR project seeks to improve the testing and reporting of software product usability and thereby reduce the uncontrolled costs of poor usability. Attendees included prominent industry representatives from software suppliers and organizations with large software procurements.

Several IUSR participants have been performing pilot tests on the current version of the CIF to determine how well it works for usability reporting and to determine its usefulness in software procurement. Tests covered business applications, Web usability, and a variety of consumer software. Pilot testing was performed in conjunction with a partner, so that customer/supplier pairs each tested the CIF and collected data about its use. The CIF has proven to be stable under a variety of test types during the pilot tests and were prepared for submission into the standardization process of the National Committee of Information Technology Standards (NCITS) in January 2001. While the CIF has only been applied to software usability in pilot testing so far, many of the workshop participants believe that the scope of the CIF should be extended to cover user testing of hardware. The suitability of applying the CIF for hardware testing is under further study. More information is available at http://www.nist.gov/iusr.

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NIST CO-HOSTS INTERNATIONAL LABORATORY ACCREDITATION COOPERATION (ILAC) 2000

NIST was a co-host and active participant in the ILAC 2000 General Assembly held in October 2000, in Arlington, VA. ILAC is the worlds principal international forum for the development of laboratory accreditation practices and procedures, the promotion of laboratory accreditation as a trade facilitation tool, the assistance of developing accreditation systems, and the recognition of competent test facilities around the globe. Several NIST representatives gave presentations in workshops on laboratory accreditation and international trade, participated in ILAC committee activities, and represented NIST in the General Assembly. A major achievement was the signing of an ILAC Mutual Recognition Arrangement (MRA) by the National

Voluntary Laboratory Accreditation Program (NVLAP) and 36 other laboratory accreditation bodies from a total of 28 economies around the world.
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NIST HOSTS TRAINING SESSION ON MEASUREnet-GOV SYSTEM

In Nov. 17, 2000, an Oklahoma state metrologist, conducted a training session on Youden Chart Analysis of Round-Robin Data on the MEASUREnet-gov system, an Internet-based interactive video conferencing system that was established by NIST to aid training and collaborative work between NIST and state metrology laboratories.

Interlaboratory comparisons have been conducted among the state weights and measures laboratories since 1981. This session was one of a series of training programs requested by the state metrology laboratories to enable them to assume responsibility for coordinating the round-robin activities of the regional Measurement Assurance Programs and analyzing and reviewing the data collected. This was previously a NIST function.

The 1 hour class included a presentation that helped explain the Youden analysis equations and process. The presentation and an associated spreadsheet are available under "Technical Resources" on the following Web site: http://www.nist.gov/labmetrology.

At present, 11 laboratories are participating in the pilot test of the MEASUREnet-gov system: Puerto Rico, Oklahoma, Arizona, California, Idaho, Maine, Connecticut, Michigan, Minnesota, North Carolina, and Georgia. This system facilitates training and collaboration through the use of innovative software and saves travel time and money.
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KEEPING TABS ON THE SITE WITH LASER LIGHT

Greater than 5 % of the labor costs in a typical construction project are devoted to monitoring the status of activities such as the state of excavation, the location of building materials (such as gravel and structural steel), re-work (fixing things built wrong) and establishing as-built information about the project.

To relieve this time-consuming and costly burden, NIST researchers are creating, testing and standardizing methods for tracking activities about a construction site. Their approaches make use of three-dimensional laser metrology, wireless communications, interactive web browsers and a remote time-based project database.

One project under way is the use of a high-speed laser imaging system that enables users to determine the status of earth-moving activities. The new tool, called LIDAR (for Light Detection and Ranging), can scan a construction site and supply off-site contractors, subcontractors and owners with 3-D information. Among the types of precise, real-time data derived from LIDAR data would be cut-and-fill requirements, quantities of material placed or removed, and rates of material removal.

Linking all these facets are efforts to develop wireless interoperability protocols and data standards. Such advances will permit plug-and-play compatibility among sensors, data gathering systems, machines and data basesall keys to successful automation. NIST's advanced construction initiatives have drawn industry interest. Collaborative research projects with U.S. construction companies, software vendors and hardware manufacturers are planned for 2001. For more information, contact Geraldine S. Cheok, (301) 975-6074.
Media Contact: John Blair, (301) 975-4261; john.blair@nist.gov.

APRIL CONFERENCE TO SHOWCASE 2000 BALDRIGE RECIPIENTS

The newly named recipients of the 2000 Malcolm Baldrige National Quality AwardDana Corporation-Spicer Driveshaft Division (Toledo, Ohio), KARLEE Co. Inc. (Garland, Texas), Operations Management International Inc. (OMI)(Greenwood Village, CO) and Los Alamos National Bank (LANB)(Los Alamos, NM) will present details of their exceptional business and performance practices at the Quest Excellence XIII conference. OMI is the first water treatment company and LANB is the first bank to be honored with the award.

Presentations covering all seven categories of the Baldrige Award criteria will be made by the CEOs and others in the winning companies. Education and health care sessions also will be offered.

Ninety-five percent of this year's Quest for Excellence conference attendees indicated that the information available prepared them to improve their organizations.

The conference took place in April 2001, at the Marriott Wardman Park Hotel, Washington, DC.

Further information on the Baldrige Award recipients and the Baldrige National Quality Program is available by calling (301) 975-2036 or on the World Wide Web at www.quality.nist.gov.
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POLISH UP YOUR GLOSS MEASUREMENTS AT NIST

The glossy surface on a shiny new car is more than just eye candy—in car paints, for example, the quality of the gloss tends to correlate with the durability of the finish. Shine, or properly "specular gloss," is the perception of a mirror-like surface. The glossiness of a surface is second only to color as the most important attribute of products such as automotive coatings, textiles and papers.

To help manufacturers monitor and assess specular gloss, NIST has launched a new Special Test Service to calibrate gloss reference standards. Gloss measurement is not straightforwardit is determined relative to a standard, generally in a polished piece of black glass, and depends on experimental conditions such as spectral distribution of the light, incident and viewing angles. A variety of standard geometries are used to determine the specular gloss of materials. These are selected based on their ability to produce optimum discrimination between samples and to correlate with visual rankings.

The NIST facility is built around a newly rebuilt reference goniophotometer—an instrument that measures light flux as a function of angles of illumination or observation—and a newly created primary gloss standard (three wedges of highly polished, high-quality optical glass). The new service offers calibration measurements of industry working gloss standards at the specular geometries of 20°, 60° and 85°, in compliance with ISO 2813 and ASTM D523 documentary standards.

For details, contact Maria Nadal, (301) 975-4632. An online index of other NIST calibration services for optical radiation may be found on the World Wide Web at http://ts.nist.gov/ts/htdocs/230/233/calibration/users/users7.html.

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TESTS CERTIFY "SMART" BUILDING PRODUCTS

Digital automation and control technologies have been widely available for more than a decade, yet structures with integrated building services remain more of a promise than a reality.

That is, until now.

At a recent NIST workshop, testing began for equipment and product compliance with the BACnet communication standard. BACnet stands for Building Automation and Control networks. The standard enables building control systems made by different vendors to work together and be controlled from a central location. NIST and its industry partners developed both the standard and the testing methods and tools for it under the auspices of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

The partners believe that BACnet integration of control devices will optimize operations, improve safety and reduce maintenance costs. The NIST workshop on BACnet compliance test procedures set the stage for full-scale product compliance tests beginning in February by the newly established BACnet Manufacturers Association (BMA). The BMA hopes the tests will assure building owners that devices they purchase from different manufacturers can be integrated. Products that successfully pass the tests will be able to display the BMA logo and will be listed on the Associations web site, www.bacnetassociation.org.

The draft testing standardASHRAE 135.1P, Method of Test for Conformance to BACnetis open for public review and comment through Jan. 30, 2001.

For technical information, contact Steven Bushby, (301) 975-5873.

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NEW BOOK, WEB SITE CAN HELP MEDIA FEATURE NIST AT 100

Consider some of the economy-building, life-improving advances of the past 100 years—image processing, DNA diagnostic "chips," smoke detectors, automated error-correcting software for machine tools, atomic clocks, the scanning tunneling microscope, pollution-control technology and high-speed dental drills—and then tell how theyre all linked together. If you said the National Institute of Standards and Technology, move to the head of the class.

Founded on March 3, 1901, as the National Bureau of Standards, NIST was the Federal Government's first physical science research laboratory and has served throughout the century as a "behind-the-scenes" specialist for industry, science, government and the public. Its research, measurement tools and technical services are integrated deeply into many of the systems and operations that, collectively, drive the economy—manufacturing cells, satellite systems, communication and transportation networks, laboratories, factories, hospitals and businesses.

Reporters and editors are encouraged to help NIST celebrate its centennial year by featuring the agency and first century of service to America in articles, online stories and broadcast reports. All of the historical information needed is now available in *NIST at 100: Foundations for Progress,* an extensive, illustrated book. Single printed copies may be requested by fax (301-926-1630) or e-mail (media@nist.gov).

A full-color World Wide Web site, www.100.nist.gov, complements the printed text and provides links to additional material.

Non-media requests for single copies of *NIST at 100: Foundations for Progress* may be faxed to the number above or e-mailed to inquiries@nist.gov.

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NIST REFERENCE IMPLEMENTATION TO BE USED THROUGHOUT VETERANS HEALTH ADMINISTRATION

The Veterans Health Administration (VHA) selected NIST's Enterprise Single Sign On (ESSO) reference implementation for use within VHA hospitals. NIST developed ESSO in response to the need within VHA for a single logon to all of their hospital systems. Part of the Department of Veterans Affairs, VHA is one of the nation's largest healthcare providers with 270 hospitals. ESSO is currently being installed in all VHA hospitals. The Web site is http://www.nist.gov/va/.

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CALIBRATION STANDARDS FOR DETERMINATION OF MOLECULAR MASS

NIST certified three new polyethylene standards for calibration and performance evaluation of size exclusion chromatographs. Size exclusion chromatography (SEC) is the most convenient and widely used method for determining the mass distribution of synthetic polymers. The molecular mass distribution is the molecular characteristic of polymers that controls both processibility and properties. The three new mass standards, together with three previously certified standards, cover the range from 5000 g/mol to 200 000 g/mol. These provide the polymer industry with an adequate set of molecular mass calibrants for polyethylene.

Calibrations of SEC are carried out with a series of narrow fraction molecular mass standards covering the mass distribution range of the polymer of interest. Narrow fraction molecular mass polymers are only available for a selected few polymers. In the absence of suitable standards, crude approximations are used which introduce uncertainties in the measurement results. Although polyethylene is the most prevalent synthetic polymer, there are no commercial standards consisting of narrow mass fractions, other than those provided by NIST. The lack of commercial standards arises from difficulties obtaining narrow molecular mass fractions of polyethylene and in measuring absolute molecular masses by light scattering or osmometry at temperatures as high as 150 °C. The new standards were prepared from fractionation of a broad distribution polyethylene that provided the fractions previously certified by NIST.

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KEY NIST CONTRIBUTIONS RESULT IN DEPLOYMENT OF NEW E-COMMERCE STANDARDS SUPPORTING ELECTRONICS MANUFACTURING

Standards resulting from NIST's technical and leadership contributions in support of electronics manufacturing recently have been deployed in industry, as evidenced at the IPC APEX trade show in San Diego in January. Four vendor booths participated in the demonstration of the IPC-2540 standards for factory equipment communications; the IPC certified the first commercial software product as being IPC-2511A (GenCAM) compliant; and the National Electronics Manufacturing Initiative (NEMI) released three Virtual Factory Information Interchange Project (VFIIP) draft standards (IPC-2571, 2576, 2578) to the ANSI standards process through the IPC. The IPC-2500 series of standards is being developed to enable e-commerce in the $20 billion U.S. printed circuit boards (PCB) and printed circuit assemblies (PCA) market.

NIST has been working with both IPC and NEMI on the development of the IPC-2500 standards. A NIST staff member co-leads the NEMI committee that initiated the factory floor and supply chain standards, and now oversees IPC standardization of the latter. Another NIST staff member is the co-chair of the IPC Data Transfer Solutions (DTS) committee. The DTS committee manages the development of the IPC 2500 standards.

The NEMI/IPC collaboration has created a pipeline for standards development. NEMI initiates a standards activity when a need is identified. A group is formed to research and test a protocol or data format. The results are then handed over to the DTS committee to manage the draft standard as it is moved by IPC through the ANSI standards process. IPC can also take the standards into the international arena through the IEC (International Electrotechnical Commission) publicly available specification (PAS) mechanism for creating standards. Additionally, NEMI plans to increase industry support for these standards by encouraging RosettaNet to incorporate their use in future Partner Interface Process Specifications (PIPs).

For additional information and copies of the standards, please visit http://www.gencam.org/. Additional

explanatory information on the 257x series, collectively known as the Product Data eXchange (PDX) standards, can be found at http://www.fis.nemi.org/.
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NIST'S TEST TOOLS FOR INTERNET TELEPHONY WILL HELP INDUSTRY CONVERGE DISJOINT APPLICATIONS

NIST recently released NIST SIP V0.9, the first component in a planned suite of instrumented protocols and related test tools intended to serve the emerging Internet telephony industry. In its initial release, NIST SIP provides a reference implementation for the Internet Engineering Task Force (IETF) Session Initiation Protocol (SIP). The protocol appears likely to become the basis for signaling and dynamic service creation in peer-to-peer personal communications applications.

By providing natural integration with Web, e-mail, and voice telephone technologies, SIP will help industry to converge formerly disjoint applications. Examples of such applications might include call-forwarding or messaging services controlled by electronic calendars and business call centers that integrate automated voice response with Web page interactions. In addition to evolving in concert with the relevant IETF specifications, NIST SIP provides a public-domain software platform for industry and university researchers to experiment with service creation and with open, component-based approaches to implement distributed services from a loosely coupled set of composable components.

In the near future, industry expects to agree upon softswitch architectures, along with supporting service composition mechanisms. Anticipating these developments, NIST researchers already contribute to industry efforts to develop application programming interfaces (APIs) for SIP.
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ELECTRODEPOSITED Pb-FREE SOLDER AND WHISKER PREVENTION

A technology important to electronics manufacturing is the electrodeposition of Sn-based protective coatings to guarantee solderability. It has been known for many years that the use of pure Sn as a protective coating on copper and copper alloys can result in the growth of hair-like Sn crystals known as "whiskers." These whiskers can be 1 μm to 2 μm in diameter and several millimeters long, and are capable of carrying 10 mA to 20 mA of current. It has also long been known that the addition of Pb to the coating effectively suppresses whisker growth, but, with the advent of Pb-free electronics finishing, the risk of tin whiskers is again a significant concern. With today's finer pitch devices, the whiskers can cause electrical shorts and failure.

Whiskers are generally believed to grow to relieve residual stress in electrodeposited Sn. However, the origin of this stress is not at all clear. In the more than 50 years since the first documented observation of tin whiskers, a fundamental mechanism of tin whisker formation has never been fully elucidated. Without a good understanding of the mechanism of whisker growth, the electronics industry has yet to devise a good test for determining the propensity for coatings to grow whiskers. In the current program, NIST researchers are focusing their efforts on developing an understanding of whisker formation in pure Sn and Sn-Cu alloy electrodeposits. This study is being carried out within the context of a study of the effect of plating methods on grain size, residual stress and alloy composition, and is expected to indicate plating approaches for prevention of whisker formation.

The NIST study has revealed seven types (shapes) of tin whiskers that form on matte and bright pure Sn and Sn-Cu alloy coatings. The type is dependent on substrate material, such as rolled annealed Cu, electrodeposited Cu, evaporated Cu, rolled phosphor bronze, rolled brass, and mild steel. However, the study found that Sn whisker growth could be prevented on a substrate/Sn deposit combination known to grow whiskers by depositing a thin (0.1 μm to 2.0 μm) Ni coating on the substrate before deposition of the Sn or Sn-Cu coating. Currently the investigation of whisker formation is focused on intermetallic formation by copper-tin interdiffusion, substrate effects on tin nucleation, and inclusion of organic or inorganic impurities in the tin deposits. Special emphasis is being focused on the measurement of residual stress using x-ray diffraction analysis.
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CHARACTERIZING NANOSCOPIC DISORDER USING QUANTUM MOLECULAR TOPS

Researchers at the NIST Center for Neutron Research (NCNR) have recently carried out the first U.S. studies by cold neutron spectroscopy of molecular disorder induced by nanoscale confinement. In this work inelastic neutron scattering was used to probe the rotational dynamics of molecules adsorbed into porous glass disks with pores ranging from 2.5 nm to 7.5 nm.

In bulk molecular solids at ≈5 K, the molecular rotors are classically forbidden from rotating due to the surrounding molecular field. However, quantum mechanics allows the molecules to rotate by tunneling through the barrier. The differences observed between the quantum tunneling in the bulk and confined molecular solids provide a powerful probe of the structure of the confined molecular solid. This information, which is key to useful properties of nanostructured materials, is very difficult to obtain using conventional structural methods. Using neutron inelastic scattering, NCNR scientists have measured the effect of both pore size and the surface chemistry on the degree of disorder in the local molecular environment for molecules such as CH_3I confined in porous glasses.

Thus, novel cold neutron techniques that probe the dynamics of the adsorbed solid rather than the static structure could prove very useful in characterizing the next generation of engineered nanoporous materials, with applications including chemical separation.

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IMPROVING CRYSTAL RESONATORS WITH NEW MATERIALS

Accurate time and frequency standards depend critically on crystal resonators made of quartz because this material has extremely low internal dissipation of mechanical energy. This dissipation is measured by the *Q* of the resonator which is typically about three million for a 5 MHz device. Achievement of this high a *Q* value was the result of extensive research in the 1950s into the mechanism of energy loss and the development of techniques to eliminate impurities and to grow more perfect crystals of quartz. Recently, a new class of synthetic crystals based on langasite—a lanthanum-gallium-silicate—and its isomorphs, langanite and langatate, have exhibited properties that could make them useful substitutes for quartz in many applications. However, the *Q* values are seldom as high as in properly prepared quartz. NIST has developed a novel method of measuring the *Q* of piezoelectric crystals that minimizes energy loss to the surroundings and, hence, can measure the internal dissipation with unusual accuracy. Application of this method at a variety of temperatures and frequencies has exposed several mechanisms of internal loss in the langasite type materials and is being used to guide the development of manufacturing techniques that will insure the consistently high values of Q required for the next generation of crystal resonators.

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NEURAL NETWORK TECHNIQUE USED FOR MODELING NONLINEAR ERROR DATA

Researchers at NIST have developed a new technique for modeling nonlinear error data that can reduce the amount of testing that a linear model would require. This technique can also be used to predict the errors over a full set of test points, based on only the selected subset of test points. It is expected that this nonlinear modeling approach can be incorporated into the NIST High-dimensional Empirical Linear Prediction (HELP) Toolbox, which will soon be available on the NIST Web site.

A Neural Network (NN) Toolbox was used in conjunction with second-order Gradient Search software to build five-layer NN models of simulated nonlinear data. The limitations of this approach were explored in terms of speed of convergence, noise immunity, and level of complexity. In modeling a five-parameter bandpass filter, for example, it was found that a five-fold improvement in the mean squared error was obtained using a neural network nonlinear modeling approach versus a linear model when the parameter values of the filter were changed by 20 %.

Other examples of interest were examined for this purpose, including the data from a thermal-based voltmeter. Using a 45-parameter model, the NN modeling showed significantly better results than linear modeling when the number of test points was less than 62. A paper describing this research was presented at the IEEE Instrumentation and Measurement Technology Conference (IMTC) 2000 held in Baltimore, MD.

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VERY LOW-NOISE SINGLE ELECTRON TUNNELING TRANSISTORS

A team of NIST scientists, in collaboration with workers at NTT (Nippon Telephone and Telegraph) in Japan, have confirmed extremely low noise in Si-based single-electron tunneling (SET) transistors.

SET devices allow the measurement or control of the motion of single electrons; this ability has the obvious attraction for NIST that each electron has exactly the same charge, and thus SET devices hold the potential to form a fundamental standard of charge or current. At present, NIST workers are pursuing a fundamental standard of capacitance by pumping a known number of electrons onto one plate of a capacitor.

One of the difficulties with SET devices is the well-known charge offset problem, which manifests itself as a random phase offset to the periodic dependence of current on transistor gate voltage. This makes it difficult to parallelize or integrate many SET devices, since one

does not know *a priori* whether a given gate voltage turns the device on or off. For example, in the case of the capacitance standard, this problem means that the standard must be stopped every so often to retune the gate charges.

Researchers at NIST have been working for several years, without success, at overcoming the charge offset drift in metal-based SET transistors. A typical result is that such devices will significantly drift off from their original operating point within a few days. A new collaboration with workers in NTT have allowed NIST scientists to do the same measurements in Si-based devices. In the first such measurement, it was observed that, for a period of 3 weeks, the charge offset drifted by less than 0.5 %. In addition, the short-term noise is about one order of magnitude smaller than similar metal-based devices.

This work is continuing, with the next steps being to confirm this significant improvement in a second Si-based device, and to investigate the crucial materials difference(s) causing this significant improvement in the Si-versus metal-based devices.

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100 mV PEAK OUTPUT DEMONSTRATED FOR THE JOSEPHSON WAVEFORM SYNTHESIZER

For the first time NIST has been able to synthesize waveforms with peak output voltages exceeding 100 mV using the Josephson waveform synthesizer. This two-times increase in voltage was possible by summing the output voltage of two 4100-junction series arrays. Achieving large output voltages has been difficult with the Josephson synthesizer because the arrays are biased with broadband dc to 18 GHz input waveforms that are not easily divided and summed from different circuits. Fortunately, the recently developed ac coupling technique that divides the low (< 10 MHz) and high frequency input signals allows researchers to drive multiple arrays in parallel at high frequency and to bias the arrays in series at low frequency. Combining the low frequency output waveforms of N arrays in series results in an N-fold increase in output voltage compared to a single array. This is the first time that the output voltage of two arrays has been combined for ac waveforms. Researchers have demonstrated waveforms with 121 mV peak voltage by driving two arrays with a 7.5 GHz sine wave and a 5 Gbit/s digital code input signals. The harmonic distortion for a synthesized 5 kHz sine wave was more than 100 dB below the fundamental. This is the lowest distortion measured for any Josephson synthesizer circuit and it demonstrates that both arrays have good operating margins.

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NEW X-RAY ABSORPTION TECHNIQUE TO STUDY CONCRETE

The amount and movement of water in the microstructure of concrete controls the material properties. The ability to measure the presence and movement of water in concrete and other porous materials has recently been greatly enhanced using an x-ray absorption technique. This technique was invented at the Technical University of Denmark and used in the first prototype unit. The second such x-ray absorption unit in the world has recently been delivered to NIST. The transmission of x rays through a specimen is indicative of the materials local density, which can in turn be related to water movement within the material. This unit, which is totally automated and computer-controlled, has already been successfully applied to examining water movement during drying/curing of hydrating cement pastes and the influence of shrinkage-reducing admixtures on drying kinetics and the resultant moisture spatial distribution. It can move in three dimensions, and scan in two dimensions, with a resolution of 0.1 mm. The use of this unit is expected to become a standard technique in the building materials community, and it should be equally applicable to other porous materials.

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NIST DEVELOPS NEW FORM OF NEUTRON RADIOGRAPHY PROVIDING FINE INTERNAL DETAILS

Physicists from NIST and the University of Melbourne, Australia, have recently demonstrated for the first time a novel neutron phase-contrast imaging technique without the usual requirement of an interferometer. This form of phase-contrast imaging uses the transverse coherence properties of a neutron wave to enhance images, particularly of boundaries and edges. This technique is different from conventional neutron radiography where only the bulk features of a sample are visualized. The results of this research have been published recently in the journal *Nature*.

The experiments were performed at the NIST Center for Neutron Research, using a position-sensitive two-dimensional Charged Coupled Device neutron detector with nominal resolution of about 50 μm. A lead bullet and a common wasp were chosen as specimens because these are representative of difficult cases for radiography by traditional methods with either x rays or neutrons.

One of the most important aspects of these experiments is that the researchers were able to extract the quantitative phase values, as well as the phase-contrast images. These phase values are critical to the interpretation of the images obtained. This phase extraction is possible by the application of the so-called paraxial "Transport of Intensity Equation" (TIE) to the image intensity profiles, which allowed the researchers to employ a simple, robust experimental setup without the need for stringent environmental control required in a typical interferometry experiment.

These experiments open the exciting possibility of investigating very fine structural details such as fractures and strain in commonly used industrial components, magnetic domains, and thin film-substrate interface boundaries. Further experiments are planned in the near future using polarized neutrons and magnetic samples.

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COMPACT FREQUENCY STANDARD DRIVEN BY A DIODE LASER DEVELOPED BY NIST

In recent work at NIST Boulder, researchers have developed a small, 4.6 GHz frequency standard using a vertical-cavity surface-emitting laser (VCSEL) that pumps a cesium atomic vapor in a small cell structure. Design information developed in this program indicates that, even using commercially available components, the package for the standard can be made as small as 10 mm × 10 mm × 20 mm, and that the system might operate at a power as low as 100 mW. This standard has potential applications in areas such as wireless telecommunications where good synchronization is needed to assure efficient data transfer between network nodes. In these systems, it is particularly important to maintain reference timing at each node, even when external synchronization (for example, via GPS signals) is lost. Thus, the industry is searching for compact, high-stability oscillators that can meet this "holdover" requirement. The timing uncertainty of these devices is better than 10 μs over 1 day, which meets the industry requirements. Current research efforts are aimed at understanding the fundamental physics of operation of these standards and further improvement of their performance.

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AN OPTICAL-FIBER NETWORK FOR FREQUENCY COMPARISONS ESTABLISHED IN BOULDER

In a joint program with the city of Boulder, the Department of Commerce, the University of Colorado (UC), and the National Center for Atmospheric Research, an optical-fiber network—BRAN (Boulder Research and Administrative Network)—has been installed connecting various organizations dispersed throughout the city. A number of network fibers have been assigned to NIST; including a dark pair (no included optoelectronic interfaces) of fibers. These fibers connect optical systems at NIST to systems at JILA on the UC campus. The distance along the fiber between these two sites is approximately 3.5 km. Exceptional microwave and optical frequency standards are located in these two locations, which provide the opportunity to study the performance of this direct fiber connection.

In preliminary experiments, NIST and JILA have demonstrated high short-term-stability transfer of frequency across the network. They first modulated the output of a 1.3 μm laser at 2.3 GHz using a source locked to a hydrogen maser in the NIST time scale. This was transferred to the university over BRAN and then back to the division. The uncompensated diurnal variations of the time delay between the two sites were about 140 ps, and can be controlled well below this level.

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STICK-SLIP MOTION OF A STRESSED COULOMB CRYSTAL OBSERVED BY NIST SCIENTISTS

NIST scientists in collaboration with the University of California at San Diego, have recently identified earthquake-like disturbances in what had previously been considered to be stable nonneutral-plasma crystals. Such a crystal, confined in a Penning trap with its rotation locked to a rotating electric field, has potential applications in atomic frequency standards and quantum logic. The value of these crystals lies in their high degree of order and stability, so it is important to learn how to control these unexpected motions.

The experiments demonstrated that the application of a small torque produces sudden angular jumps or "slips" of the crystal orientation spaced by intervals where the crystal orientation is phase-locked or "stuck" relative to the rotating field. The angular slips follow

power-law frequency-versus-amplitude spectra, where the power-law exponent depends on the amount of applied torque and is therefore not universal. Positive correlation is measured between the waiting time between slips and the amplitude of the following slip.
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DETERMINATION OF THE RELATIVISTIC RED SHIFT BY NIST IN BOULDER

In a recently completed project, involving a NIST researcher, the relativistic red shift correction due to gravity was estimated with a relative uncertainty of 2×10^{-17}. An accurate estimate of the relativistic red shift is an important factor in the list of systematic frequency shifts that must be determined in order to evaluate the performance of NIST-F1, the NIST cesium-fountain frequency standard; in fact, the relativistic red shift is the largest frequency bias for this standard. Moreover, the importance of this shift will become even greater in the future as frequency standards of increasing accuracy are developed.

The researchers used three different methods to arrive at their estimate—(1) a 1998 global gravitational model produced by NASA and the National Imagery and Mapping Agency, (2) a 1999 regional, high-resolution geoid model, and (3) recent measurements made by the National Geodetic Survey of a reference marker on the NIST site. Through a critical analysis of these three methods, the researchers estimate that the frequency correction for NIST-F1 in its current location is -1805.4×10^{-16}, with an estimated relative uncertainty of 0.2×10^{-16}. This is well below the NIST-F1 uncertainty of 1.5×10^{-15}, so at this time the red-shift correction is not of particular concern. It is worth noting that when the division moves this standard to a different floor of the building, which should happen in about a year, the correction will have to be changed.
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NIST PERFORMS COMPARISON OF FREQUENCY STANDARDS

A post-processed time scale, involving an ensemble of five hydrogen masers, has been developed by a NIST scientist in Boulder to serve as a reference for comparing primary frequency standards. During the last 2 years, this time scale has been used to evaluate the relative frequencies of NIST-7, an optically pumped cesium-beam standard, and NIST-F1, the cesium-fountain frequency standard. The comparisons indicate that the frequencies of NIST-7 and NIST-F1 have remained in agreement within their measured uncertainties over the last two years, thus adding confidence to the methods used for evaluating the uncertainties of the standards. Having completed this overlap of operation with good results, NIST-7 will now be taken out of operation.

It is particularly important to note that this scale allows comparison of frequency standards not operated at exactly the same time. The stability of this time scale, called AT1E, is less than $\sigma y(\tau) = 1 \times 10^{-15}$ for averaging times from 1 d to 100 d, with a minimum near 3×10^{-16} at about 20 d. When combined with frequency comparison data obtained through various satellite-based methods, this time scale also provides a means for absolute comparisons of the frequencies of NIST primary frequency standards with those of other countries. Measurements show remarkably good agreement among the frequency standards of NIST, France, and Germany. Considering that these standards are of quite different designs, it is clear that the measurement of frequency at these levels is in very good shape. The more recent comparisons of NIST and German cesium-fountain frequency standards have been accomplished using a two-way time-transfer link between these two labs. This link supports comparisons at a relative uncertainty of less than 1×10^{-15}, more than a factor of two better than other comparisons, which are made using th common-view GPS method. The German and NIST fountain standards were found to agree within their uncertainties.
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NIST SCIENTISTS DEVELOP DECOHERENCE-RESISTANT QUANTUM MEMORY USING TRAPPED IONS

NIST scientists in Boulder have recently demonstrated operation of a decoherence-free quantum memory using trapped ions. A quantum memory stores information in superposition states of a collection of two-level systems called “qubits.” Quantum computation works by operating on information in the form of such superpositions, and robust quantum memories are therefore essential to realizing the potential gains of quantum computing. However, interaction of a quantum memory with its environment destroys the stored information, a process called decoherence. Many proposed quantum memories decohere via an environment that has the same coupling to each qubit. In the trapped-ion demonstration, information from an arbitrary qubit stored in a single ion is encoded into a decoherence-free subspace of two ions. The decoherence-free subspace states are invariant

under the coupling to the environment, protecting the encoded information. The experiments on this memory concept involved measurement of the storage time under both ambient conditions and under interaction with an engineered noisy environment. The researchers found that encoding the qubit information into the decoherence-free subspace increases the storage time by up to an order of magnitude.

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TEST OF BELL'S INEQUALITIES USING TRAPPED IONS

In experiments using trapped, laser-cooled ions, NIST researchers in Boulder have demonstrated a violation of Bell's inequalities. These mathematical inequalities provide a basis for experimental tests whose results can distinguish between quantum mechanics and local realistic theories. Many experiments have been performed that are consistent with quantum mechanics and inconsistent with local realism. Because the conclusions derived from these experiments have generated considerable debate, the experiments are still being refined in order to overcome "loopholes" that might affect the results. NIST's experiments are the first to demonstrate violation of Bell's inequalities with massive particles ($^9Be^+$ ions) obtained by use of a complete set of measurements. In addition, the high detection efficiency of the experiments eliminates the detection loophole for the first time. All previous experiments have had detection efficiencies low enough to allow the possibility for the subensemble of detected events to agree with quantum mechanics even though the entire ensemble satisfies Bell's inequalities.

The NIST experiments prepare a pair of two-level atomic ions in a repeatable configuration. Next a laser field is applied to the particles; the classical manipulation variables are the phases of this field at each ions position. Finally, upon application of a detection laser beam, the classical property measured is the number of scattered photons emanating from the particles. The Bell signal B was constructed using the results for four sets of phase parameters. Analyses of the photon count distributions indicate that the Bells signal was $B = 2.25 \pm 0.03$, a result that clearly exceeds two, the maximum value allowed by local realistic theories of nature.

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SOLAR CELL ELECTRON TRANSFER DYNAMICS MEASURED BY NIST SCIENTISTS

Inexpensive solar-to-electric energy converters based on organometallic dyes impregnated on nanoparticle substrates of titanium dioxide (TiO_2) and other related semiconductors are being explored as replacements for silicon-based solar cells. These new solar cells could lead to low cost (less than $1/W) photovoltaic alternatives. Applications of the dye-sensitized photoelectrochemical cells include integrated power systems for consumer electronics, smart cards, electrochromatic windows, mirrors, and eyewear. The benefits of these devices include those derived from renewable energy sources—decreased emission of greenhouse gases and pollutants and the economic benefits of the lower cost energy sources.

Determining detailed mechanisms and underlying materials properties of such devices is key to understanding their function and improving solar collection and current-generating efficiencies. NIST researchers were the first to apply time-resolved infrared spectroscopy to unambiguously reveal that electron injection from excited electronic states of the dye molecules (e.g., different complexes of Ruthenium) to the TiO_2 occurs on the femtosecond ($<10^{-14}$ s) timescale. Groups worldwide now accept their technique and use their findings in related studies. The researchers have also examined detailed back electron transfer and electrolyte quenching dynamics in working cells by applying nanosecond ultraviolet and visible transient absorption spectroscopy. Their findings indicate that subtle changes in dye molecular structure affect the electron injection yields and overall recombination rates. One exciting discovery is that substituting tin oxide (SnO_2) for TiO_2 sufficiently changes the acceptor levels and electronic coupling efficiencies to produce cells with absorbed photon-to-current efficiencies approaching 40 %, constant across the visible spectrum. These findings suggest that minor modifications to the adsorbed dye and substrate properties could lead to cells with efficiencies approaching theoretical conversion limits.

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NIST DEVELOPS BENCHMARKING WEB SITE USABILITY METHODOLOGIES (CIFter)

NIST is developing methodologies to measure the usability of Web sites. Empirical evidence from

research and commercial sources indicates that Web sites suffer from a lack of usability. Measuring usability of Web sites is more complicated than measuring usability of desktop applications. One difficulty is defining typical users and typical tasks, given the diverse audience of users. A second difficulty relates to the wide variety of measurement methodologies that are the repertoire of the usability engineer. Another major confounding factor is that Web sites are dynamic, i.e., there are day-to-day, minute-to-minute, and query-to-query differences in the content of sites.

To address these issues, NIST initiated a project called CIFter (Common Industry Format for Testing Usability Evaluation Reports). NIST then recruited approximately 10 groups of usability evaluators to begin the CIFter study. A CD with the Web site snapshot, tasks, and NIST WebMetrics tools was released to the evaluators on Dec. 31, 2000. Evaluation results will be submitted to NIST in the next 6 months and analyzed to determine the value of using such collections to derive benchmarks of usability engineering methodologies.
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NIST RESEARCHERS DEMONSTRATE SOFTWARE TO MODEL FAULT RECOVERY IN OPTICAL NETWORKS

In January 2001, at a meeting of principal investigators held by the Defense Advanced Research Projects Agency (DARPA), NIST researchers demonstrated MERLiN, a software tool for modeling fault recovery algorithms in optical networks. The researchers used the tool to model a fault restoration algorithm developed at George Washington University (GWU) as part of a collaborative project funded by DARPA to investigate various attack scenarios and recovery techniques for optical networks. The GWU algorithm pre-computes a set of alternative paths for each optical link in a given network topology, so that when a fault occurs, a backup lightpath can be selected quickly and automatically. The MERLiN model of the GWU algorithm allows a researcher to construct various network topologies, simulate faults in the network, and then observe restoration outcomes through a graphical user interface.

This joint NIST-GWU project was initiated in October 2000 as a part of the DARPA Fault-Tolerant Networks (FTN) program, which sponsors research and development of techniques that can enhance network survivability. Researchers within the program are investigating a wide range of relevant topics, including detection of intrusions and denial-of-service attacks, domain-name system security, server replication and camouflage, and fault-tolerant network protocols. DARPA expects that other researchers, beyond the NIST-GWU team, can use MERLiN as a tool to develop and evaluate additional algorithms for fault detection and restoration in optical networks.
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NIST DEVELOPS DATA LIBRARIES FOR AIRFLOW MODELING

NIST has developed databases for use in multizone airflow modeling, such as that performed with the NIST-developed airflow and indoor air quality simulation program CONTAMW. Multizone airflow and indoor quality models enable the analysis of building airflow patterns and airborne contaminants in multizone building airflow systems. These models have been used for a number of years to support indoor air quality and ventilation research efforts, but more recently their practical application by the building industry has increased. A key step in using such models is acquiring the input data used to describe the building that is being studied. In order to achieve NIST's goal of more widespread use of these models by the building industry, an effort is in progress to assemble available input data into a form that is easily accessible by users of CONTAMW and similar programs. A number of data library files have recently been developed as CONTAMW library files, making them easy to access by users of the program. The input data in these libraries are derived from the published literature, manufacturers data, and building specific measurements. The data in these libraries include leakage characteristics of airflow elements, wind pressure coefficients, and schedules for openings and ventilation systems. These libraries have are documented in NISTIR 6585 and are available at the CONTAMW Web site: www.bfrl.nist. gov/iMZWeb.
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DESIGNER CHANNELS FOR MICROFLUIDIC DEVICES

NIST scientists are using ultrathin polymer layers, polyelectrolyte multilayers (PEMs), to control fluid flow in microfluidic devices. Microfluidic, or so-called "lab-on-a-chip," devices are miniaturized chemical and biochemical analysis systems that may one day replace conventional benchtop instruments. Plastics are emerging as ideal materials for these devices because of their low cost, chemical compatibility, and good optical properties. A given plastic, however, may not possess the right surface properties to sustain a desired

electroosmostic flow (EOF). EOF is the most common-method used to pump liquids through microchannels and EOF behavior depends strongly on the surface characteristics of a material. The researchers find that coating channels with PEMs yields greater reproducibility and, with judicious selection of coatings, tailored channels for specific chemical analysis problems. The PEMs coatings are alternating positively and negatively charged polymer layers that are held in place by electrostatic interactions. Because the direction of EOF depends on whether a surface is positively or negatively charged, the researchers find they are able to control the fluid flow in a device by coating the various arms of a channel with different PEMs. If the right coatings are chosen for the four arms of an X-shaped channel, for example, a single applied voltage will bring all four fluids to the center for mixing. In a more dramatic demonstration, the researchers coated the two halves of a channel with different PEMs and observed simultaneous bidirectional flow. Although a specific application for bidirectional flow hasnt been identified yet, it might be useful for studying reactions at the interface of two fluids or for separations. Two articles describing this work have appeared recently in the journal Analytical Chemistry and an application for a patent has been filed.

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PREDICTION OF THE ATMOSPHERIC LIFETIMES OF HALON REPLACEMENTS

Scientists at NIST have developed a new technology to allow a reliable estimation of the atmospheric lifetimes of halon replacements based on ab initio quantum mechanical calculations. The potential suitability of new industrial compounds depends in large part on an assessment of their environmental suitability. For gaseous compounds, such as potential halon replacements, a key element in this assessment is the atmospheric lifetime, which is based on the reactivity of the compound toward the hydroxyl radical. This parameter is the starting point in calculating the ozone depletion and global warming potentials of these substances. Unfortunately, simple correlation schemes have proven inadequate to predict this parameter, particularly when new functional groups are involved. Thus, it appeared that laborious laboratory measurements would be required for any new class of halon replacement considered in the Next Generation Fire Suppression Technology Program of the Department of Defense. The efforts at NIST will significantly decrease the need for these laboratory measurements.

This effort involved the calculation of rate constants at various levels of theory for a large set of reactions for which the kinetics were well known. From these calculations, an optimum approach was determined; optimum in this case meaning of sufficient accuracy but also with a sufficiently frugal use of computational resources to make routine use practical. These studies, which appeared in the *Journal of Physical Chemistry A,* Vol. 104 (2000), covered 13 partially halogenated methanes, with rate constants calculated over the temperature range 250 K to 400 K. The results agreed with experimental values typically better than a factor of two and always within a factor of four.

The technique has now been applied to five potential fire suppressants, all bromine-containing methanes, for which there was no experimental data. From the *ab initio* calculations, atmospheric lifetimes were estimated to range from 0.12 years to 1.88 years. These lifetimes, in turn, can be incorporated into atmospheric models to estimate the ozone depletion potentials of these compounds if it is decided to consider them further as halon replacements. A manuscript on this work appears in the February 2001 issue of the *Journal of Physical Chemistry A.*

Efforts are under way to extend the approach to additional classes of potential fire suppressants and to further simplify the computations.

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NIST/FIZ-KARLSRUHE PARTNERSHIP TO IMPROVE THE INORGANIC CRYSTAL STRUCTURE DATABASE FOR MATERIALS RESEARCH

The materials research community uses crystallographic data models on a daily basis to visualize, explain, and predict the behavior of chemicals and materials. Access to reliable information on the structure of crystalline materials helps researchers concentrate experimental work in directions that optimize the discovery process. Recently, the Fachinformationszentrum (FIZ) Karlsruhe and NIST have agreed to develop and enhance the Inorganic Crystal Structure Database (ICSD) on a continuing basis. The ICSD is a comprehensive collection of crystal structure data of inorganic compounds containing more than 50 000 entries and covering the literature from 1915 through the present. Work under the FIZ/NIST partnership has focused on modernizing and evaluating the ICSD. The database structure has been completely re-designed, the data converted and loaded into a relational database management system, and scientific application modules were created to analyze the results

of database searches. A major effort has been made to create a Windows-based PC product for the ICSD, which is nearing completion. This product is tabular in design, allows for searching in five general categories of chemistry, crystal data, reduced cell, symmetry, and reference data, and includes enhanced features for the characterization of materials based on lattice and chemistry search modules, and three-dimensional visualization and powder pattern simulation of inorganic structures.

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NIST HOSTS RTP 2000 AND RELATED WORKSHOP

RTP 2000: The 8th International Conference on Advanced Processing of Semiconductors was held in Gaithersburg, MD in September 2000. NIST was a co-sponsor.

Presentations by NIST staff included talks on calibration of light-pipe radiation thermometers with the NIST-patented thin-film thermocouple calibration wafer, and on the characterization of light-pipe radiation thermometers in rapid thermal processing (RTP) measurements, and on modeling of radiation thermometer measurements in RTP. Other talks at the conference related to advanced methods of temperature measurement and control described novel methods of emissivity cancellation, modulation-based temperature measurement, and non-parametric adaptive temperature control. There was strong interest in measuring temperature on the International Temperature Scale of 1990 (ITS-90), rather than local process scales, and finding ways to trace the measurements in RTP to NIST.

Prior to RTP 2000, a workshop was held at NIST on Temperature Measurement of Semiconductor Wafers using Thermocouples, with 58 participants. The workshop included talks by staff on the general properties and calibration of thermocouples; the use and properties of thin-film thermocouples; and the application here at NIST of wafers instrumented with thermocouples to calibrate light-pipe radiation thermometers in an RTP apparatus. Additional talks by industry experts described practical issues in the temperature measurements of wafers in both batch and RTP processing environments, and discussed instrumentation techniques for accurate thermocouple measurements.

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NIST DIGITAL CINEMA 2001 CONFERENCE DRAWS INDUSTRY TO DISCUSS STANDARDS

In January 2001, NIST and the National Information Standards Organization co-sponsored the NIST Digital Cinema 2001 Conference and Show. Held at NIST, the meeting attracted over 200 participants and exhibitors for this new technology. The goals of the conference were to identify the standards and interoperability requirements for the industry, identify NIST's role in developing both documented and laboratory standards and tests, and bring together the diverse stakeholders in this new technology in order to develop a synergy for new ideas and cross-industry cooperation. Participants gathered to discuss and identify standards and interoperability issues for the entire technology chain for digital cinema. This includes issues of color quality and fidelity, storage and storage management, file security, and digital rights management.

Digital cinema is the term used for the creation, production, transmission, and final display of digital content to deliver to the end-user a cinematic experience equivalent or better than film. Digital cinema is a convergent technology that employs information technology with traditional entertainment technology. Besides improvements in picture quality, digital cinema is expected to save over $500 million in distribution costs for the movie industry, in the expectation that digital files can be transmitted by satellite or other broadband means more cost-effectively than printing and shipping film. Finally, digital cinema allows local theaters to intersplice new content, such as local news features and distance learning, as part of their business models.

Conclusions from the workshop included:

- There is a need for measurements to characterize the surprisingly good performance of electronic projectors and other components of the emerging digital cinema technology. The rapid improvements of the supporting technology for capture, transport, and projection suggest research is needed on color, brightness, contrast, and frame rate for capture and presentation of digital content.
- Measurements are needed to support open standards that facilitate the interoperability, extensibility, and integration of the system components. At the same time, there should not be tiers of quality in digital cinema theaters using convergent technologies.

- Standards are needed in digital data storage to maintain the archives of digital content and for wideband transport and security. The archiving of multimedia is an international problem requiring multivendor solutions.
- Various stakeholders expressed a need for continuing discussions in similar venues of interoperability and digital rights management issues for digital cinema and for continuing outreach to imaging and other interested communities. The area of trust management—digital rights management plus computer security—is viewed by the industry as an important opportunity for NIST involvement.

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NIST HOSTS MPEG WEB SITE

As of Dec. 15, 2000, the Information Access Division is hosting the online Web site for the Moving Picture Experts Group (MPEG) of the International Organization for Standards (ISO) and the International Electrotechnical Commission (IEC).

The data site includes working group documents, contributions from industry, experimental data and associated software, and output documents from the MPEG committee. This allows committee members to upload their contribution documents and share information and working documents during the standards development process.

Future plans for the MPEG Web site include a management information system to enable users to search and retrieve documents from the system, an automated document upload and register process, virus checking on incoming documents, the ability to track membership and ad hoc groups and dialogs, and the capacity to allow individual passwords.

MPEG is the working group of ISO/IEC in charge of developing standards for coded representation of digital audio and video. Established in 1988, the group has produced MPEG-1, the standard on which such products as Video CD and MP3 are based, MPEG-2, the standard on which such products as digital television set-top boxes and DVD are based, and MPEG-4, the standard for multimedia for the Web and mobility. The current focus is on MPEG-7, Multimedia Content Description Interface, with completion scheduled for summer 2001. Work on a new standard MPEG-21, Multimedia Framework, started in June 2000 and has already produced a Draft Technical Report and two Calls for Proposals. The new Web site is expected to help enable easier collaboration within the MPEG community in developing new standards.

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MMD HOSTS SMART SENSOR INDUSTRY WORKSHOP

NIST recently hosted an industry workshop co-sponsored by the Institute of Electrical and Electronics Engineers (IEEE) on Built-in-Test (BIT) Technology for Smart Sensors and Systems. The concepts of built-in-test and self-test are widely applied for the design and testing of complex, mixed-signal electronic systems. This workshop provided a forum to review the state-of-the-art in BIT research in industry, academia, and government and to plan future directions. The workshop produced plans for promoting and expanding BIT technologies and proposed collaborations to identify and address standards needs for this technology. In particular, this work may play a future role in ongoing NIST efforts in the area of condition based maintenance of manufacturing equipment.

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JUST A PHASE? BETTER NEUTRON ANALYSIS WITH LOWER RADIATION

Researchers from NIST, the University of Melbourne, and the University of Missouri at Columbia have demonstrated a new form of neutron radiography that produces greatly enhanced images of fine structural details in test samples with relatively low levels of radiation. Conventional radiography, using either x rays or neutrons, works by detecting the absorption of the radiation as it passes through different materials. For example, the radiograph shows the “shadows” cast by tumors (x rays) or cracks in jet engine turbine blades (neutrons). But if two materials have very similar absorption characteristics or the feature under inspection is very small, radiographs often show very little detail.

In recent years, researchers have explored a more subtle effect called phase-sensitive imaging. As radiation passes through a specimen, the phase of the wave can shift at the boundary between materials of two different densities, just as light diffracts when passing through a glass of water. Because the phase-shift effect is often much stronger than the absorption effect, images based on the phase differences of the emerging waves can show much greater detail—particularly of boundaries or edges—with relatively smaller doses of radiation.

Phase-contrast x-ray images have been studied for several years, producing dramatic images of tissue

specimens that clearly show fine details. The experiments at NIST are the first to demonstrate the same phenomenon—and achieve equally dramatic image enhancement—using neutron beams, which have broad industrial applications in materials research.

Preliminary details of this research were published in *Nature,* Brief Communications, Vol. 408, November 2000. For more information, contact Muhammad Arif, (301) 975-6303, muhammad.arif@nist.gov.
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NIST, ANSI REAFFIRM PARTNERSHIP FOR U.S. STANDARDS SUCCESS

In one of the first acts in the implementation of the recently established National Standards Strategy (NSS), NIST and the American National Standards Institute (ANSI) signed a revised version of the Memorandum of Understanding (MOU)(first signed in 1995) between the two organizations on Dec. 27, 2000. The NSS was developed under ANSI's leadership by representatives of public and private-sector organizations in order to strengthen the U.S. voice in international standards arenas.

The revised MOU cements the NIST/ANSI partnership for strengthening the national voluntary consensus standards system of the United States and enhancing U.S. competitiveness in the global marketplace. In the agreement, NIST reconfirms its recognition of ANSI as (1) the U.S. member body of the International Organization for Standardization (known as ISO); (2) sponsor of the U.S. National Committee to the International Electrotechnical Commission; and (3) the U.S. representative to and member body of various private-sector regional standards organizations. NIST also pledges to facilitate ANSI's efforts to foster cooperation among U.S. private and public sector organizations engaged in standards-related activities.

In turn, ANSI recognizes and supports NIST's responsibility for coordinating federal activities in voluntary standards and conformity assessment. Under the National Technology Transfer and Advancement Act, NIST is responsible for coordinating federal standards and conformity assessment policies and activities, and for coordinating with the private sector and with state and local governments with respect to standards-related matters. NIST chairs the Interagency Committee on Standards Policy, works closely with other federal agencies and recognizes accreditation programs for conformity assessment activities.

To access an online copy of the NIST/ANSI MOU, go to the World Wide Web at http://ts.nist.gov/ts/htdocs/210/nttaa/ansimou.htm.

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NIST/INDUSTRY CONSORTIUM TO TACKLE COMPLEX POLYMER INTERPHASES

The non-stick coating on a frying pan, the coat of paint on a car bumper and the multiple layers of fibers and polymers in a tire—what keeps them together? In all three cases, it's the interface region or interphase, the area where the molecules of two materials interact with each other.

The interphase is vital to the durability and performance of nanocomposites, particle-filled materials, paints on plastics and metals, and fiber-reinforced polymer composites. In December, NIST and industry partners established the Consortium on Characterization and Modeling of the Interface and Interphases of Polymeric Materials and Systems (also known as the Polymers Interphase Consortium or PIC) to conduct a 3 year investigation of the chemical, physical and morphological characteristics of the interface/interphase region.

Material properties in the interphase are different from those of the bulk materials being joined together. With computer models, as well as with laboratory tests of both polymer blends and polymer films on various substrates, the scientists expect to learn how properties at or near the interphase region change with processing conditions and diverse external stresses (such as different temperatures and humidities). Such information could help manufacturers reduce costs for products and increase their international competitiveness. Three NIST laboratories are participating in the consortium, along with manufacturers from the plastics, paint and automotive parts sectors.

The consortium is open to new industrial members until May 15, 2001. For more information, contact Tinh Nguyen, (301) 975-6718, tinh.nguyen@nist.gov, or Charles Han, (301) 975-6772, charles.han@nist.gov.
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NEW VERSION OF CHARPY MACHINE GUIDE IS NOW AVAILABLE

Featuring a new "ready-for-the-workplace" format, the latest version of the NIST guide for the use of Charpy impact testing machines is now available. The previous edition (NIST Technical Note 1500-8) was announced last year (see the *NIST Update* issue of May 22, 2000, at www.nist.gov/update/upd000522.htm).

Charpy machines, based on the swing of a pendulum, are used to determine the temperature at which

structural materials go through a ductile-to-brittle transition. Charpy impact testing is often specified as an acceptance test for materials used in critical structures such as bridges and pressure vessels.

As with NIST TN 1500-8, the new version of the guide—recast as a NIST Recommended Practice Guide (NIST Special Publication 960-4)—explains how engineers and technicians can install, maintain and verify their Charpy impact testing machines. What makes the new publication special is its improved formatting. Featured are a smaller, easier-to-handle size and a more durable glossy hard cover so that the guide can be kept near the Charpy machine and used repeatedly.

For a free copy of the Practice Guide, contact Sarabeth Harris, NIST, MC 104, Boulder, CO 80305-3328; (303) 497-3237; sarabeth@boulder.nist.gov.
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SHORT COURSE ON RADIATION THERMOMETER MEASUREMENT OFFERED

Infrared radiometry is widely used in science and industry to measure temperature, particularly when a contact measurement would be hazardous or impossible. Practical applications span a broad range of industries, including the inspection of high-voltage power-line splices, computer circuit boards, jet engines, industrial processes, food-safety equipment and building insulation systems. While radiation thermometry is widely used, the factors that go into making accurate, reliable measurements are not always well understood by users.

To help scientists, engineers and calibration technicians better understand and control their radiation thermometer measurements, NIST has developed a 4 day course on temperature measurement by radiation thermometry. It covers the fundamentals of determining temperatures from thermal radiation; provides practical experiences in using radiometers, sources and optical elements; and trains participants in performing uncertainty analysis. It includes skill-building, problem-solving laboratory experiments and lectures on radiometry fundamentals, emissivity, blackbodies, the signal measurement equation, the temperature measurement equation and NIST temperature calibration services. Up to 16 participants can take the annual course.

The short course is offered annually. Answers to technical questions can be obtained at http://physics.nist.gov/Divisions/Div844/rtsc.html or by contacting Carol Johnson, (301) 975-2322, cjohnson@nist.gov.
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SET FOR FUNDAMENTAL MEASUREMENTS IN ELECTRICITY EXPLAINED

Single-electron tunneling, or SET, devices provide a means of manipulating individual electrons and detecting the motion of these electrons with extraordinary precision. The potential for these devices to impact the field of electrical measurement—specifically, capacitance and current standards—was first recognized in the 1980s. More recently, the performance of these devices has been pushed to the levels needed for fundamental standards and high-precision measurements.

A new paper from a NIST researcher describes the essential physics of SET devices, discusses various schemes for making capacitance and current standards based on SET devices, and covers the relevance of SET standards for fundamental constants and the International System of Units. The development of a NIST prototype SET capacitance standard is described as proceeding along three pathways: (1) a transportable version of the prototype is being constructed for direct comparison with the calculable capacitor at NIST headquarters in Gaithersburg, MD; (2) a detailed uncertainty analysis of all aspects of the standard is being developed; and (3) an effort is under way to design an easy-to-use, robust and automated system with computer control of as many functions as possible.

"There is still much room for improvement in our basic understanding of the limits on performance of these devices that attempt to transfer individual electrons as fast as possible and with as few mistakes as possible," the researcher writes. He adds that "given the relative immaturity of SET metrology, the progress reported here is impressive."

Standards based on SET devices are being pursued in other areas as well. For example, an absolute thermometer based on SET effects has been demonstrated and is available as a commercial product. In another case, regulated sources of single photons based on SET effects have been proposed in two types of semiconductor systems.

The paper, No. 53-00, is available free of charge by contacting Sarabeth Harris, NIST, MC 104, Boulder, CO 80305-3328; (303) 497-3237; sarabeth@boulder.nist.gov.
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NIST DATA FACILITATE MATERIALS DEVELOPMENT FOR NEXT GENERATION IC CHIP

Data provided by NIST have been used to facilitate development of new interlevel dielectric (ILD) films for next-generation integrated circuit (IC) chips. The drive toward increased density, enhanced performance and cost effectiveness in IC technology requires the development and integration of low dielectric constant (or low-*k*) materials as ILD for deep-submicrometer on-chip interconnects. Over the past year, a private company initiated a new research program to pursue low-*k* ILD development. Owing to successes achieved by NIST scientists in characterizing related materials in collaboration with SEMATECH, the company sought NIST assistance to provide critical characterization data on structure and properties. Under a cooperative research and development agreement (CRADA) between NIST and the company, NIST scientists provided characterization data on four different experimental materials. During a recent joint conference, the company disclosed that the NIST data correlated well with their internal dielectric data and confirmed their working model.

NIST originally developed the methodology for characterization of low-*k* ILD under a CRADA with International SEMATECH (ISMT). Internal support was also provided by the NIST Office of Microelectronics Programs. The methodology is based on a unique combination of x-ray and neutron scattering measurements that provide critically needed data on the structure of porous thin films. Over the past 3 years, more than 30 candidate materials from ISMT and its member companies have been characterized by NIST. The data provided by NIST have helped ISMT establish a low-*k* ILD database for selection of viable candidate materials for process integration. It has also enabled ISMT to provide feedback to the material suppliers for further improvement of their ILD materials.

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NIST PERFORMS FIRST MEASUREMENTS OF THE EFFECT OF STRESS ON THE REFRACTIVE INDEX OF MATERIALS IN THE VACUUM ULTRAVIOLET

The semiconductor industry is presently developing a new technology known as 157 nm lithography for producing faster integrated circuits by further shrinking circuit critical feature sizes down to at least 70 nm. This technology is based on illuminating circuit patterns that have been created on photomasks with 157 nm excimer laser radiation, and imaging these patterns onto silicon wafers using high-precision optical systems known as steppers. The focusing characteristics of the optics depend on the index of refraction of the lens materials, first measured to high accuracy at the wavelength of 157 nm at NIST. The index properties, however, are strongly distorted by stress, which is unintentionally grown into these optical materials during the fabrication process. The materials are also subject to unavoidable external stresses applied through the lens mountings and gravity. The high tolerances required for these optics necessitate accurate knowledge of the effects of stress on the index of refraction, characterized by the stress-optical coefficients.

NIST recently completed the first measurements of the stress-optical coefficients in the ultraviolet near 157 nm. These meas-urements were carried out on calcium fluoride and barium fluoride using a combination of a unique ultra-violet polarimetry system and a unique ultraviolet Twyman-Green interferometer that was developed at NIST. Lithography system manufacturers around the world are now using these values in the optical design of their 157 nm lithography systems. The NIST ultraviolet polarimetry and interferometry systems are being exploited to characterize the index inhomogeneity and residual stress-birefringence of materials at 157 nm, measurements important for evaluating the suitability of materials for 157 nm lithography optics.

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NON-LINEAR NETWORK ANALYSIS FACILITY ESTABLISHED

NIST researchers have established a new non-linear network analysis facility for the study of radio-frequency and microwave networks used in commercial wireless communication systems. With the commercialization of digital wireless communication methods, research and design engineers are pushing rf power amplifiers into non-linear operating modes in order to reduce power consumption. The non-linear responses cannot be adequately characterized with existing measurement tools, nor can the circuits be adequately simulated due to a lack of accurate circuit models and simulation tools. The new NIST facility is dedicated to the new metrology issues facing instrument manufacturers, along with the link to new measurement-based behavioral models. Improvements in these two areas will dramatically reduce radio-link design cycles and costs.

The core instrument in the new facility is a Non-Linear Network Measurement System (NNMS). NIST has one of the seven NNMS instruments located around world and the only one located in an open research environ-

ment in the Americas. The NNMS supplies large-signal stimulus signals and measures the input and output waveforms at the boundary of a device under test (up to 50 GHz). Unlike traditional linear network analysis where the goal is to determine an output-over-input ratio at given frequency (that is, a scattering parameter), non-linear network analysis tries to determine how a circuit will transform a signal rich in harmonic content. To do so, the NNMS measures periodic waveforms, separating incident and returned signals. The resulting data set is large in comparison to linear network parameters, particularly when the input is similar to a digitally modulated carrier. These data sets are being used to build new models and/or verify the non-linear circuit behavior predicted by existing models.

With the new facilities, researchers at NIST now are investigating the metrology issues in this new field, and they are cooperating with industrial and academic partners in developing new methodologies for measurement intercomparisons and measurement-based behavioral modeling. The industry is just beginning to understand the complexity of non-linear network analysis, and much work remains in developing generalized and standardized languages and understanding.

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NEW EXCIMER LASER MEASUREMENT SERVICES AT NIST

NIST recently has developed the capability to accurately measure pulse-energy density of deep ultraviolet (DUV) radiation produced by excimer lasers. This new capability now is being used to provide dose (i.e., energy density) measurement services for small-area detectors like those used in high-resolution semiconductor photolithography systems and other excimer laser applications. NIST is now offering absolute responsivity calibrations of laser dose meters at the laser wavelength of 193 nm. Additional excimer laser wavelengths will be added to this service in the near future.

The dose measurements are performed using a beam-splitter-based calibration system in which a spatially uniform beam from an ArF excimer laser is generated using a special beam homogenizer. The beam propagation properties, including uniformity or homogeneity, are fully characterized with a state-of-the-art beam profile measurement system based on a pyroelectric camera array. This uniform beam is then used to irradiate a NIST-calibrated aperture placed immediately in front of the test detector. Measurement traceability for these calibrations stems from an electrically calibrated, primary standard calorimeter developed by NIST scientists.

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COORDINATE MEASURING MACHINE STREAMLINES DIAMETER MEASUREMENTS

In an effort to streamline calibration of diameter standards, NIST researchers have carried out a careful investigation of the uncertainty of diameter measurements using their Coordinate Measuring Machine. They find that they can achieve uncertainties that are essentially identical to what is attained using more traditional methods requiring dedicated, special-purpose equipment and laborious set-up. In March they performed their first calibrations of ring and plug gages for outside customers.

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CALIBRATION OF TRANSFER IONIZATION CHAMBERS FOR SHORT-LIVED RADIONUCLIDES USED IN NUCLEAR MEDICINE DEVELOPED BY NIST

One of the properties that makes most of the nuclides used in nuclear medicine so attractive for that purpose—their short half-life—has the drawback of making it impractical to distribute these nuclides as Standard Reference Materials. Regulatory agencies such as the Nuclear Regulatory Commission and Food and Drug Administration (FDA), however, still require that users and producers of radiopharmaceuticals containing short-half-lived radionuclides demonstrate their ability to accurately measure the amount of radioactivity contained in a sample prior to administration. NIST is addressing this problem by developing calibration factors for commonly used, commercially available, re-entrant ionization chambers, or “dose calibrators.” NIST has developed a measurement model that allows determination of uncertainties involved with the derivation of the calibration factor. Moreover, the group recently expanded the program to include the uncertainty due to variation between different individual chambers and variations among similar chambers from the same manufacturer. They are currently conducting a study, using the radiotherapy nuclide ^{166}Ho, to evaluate the variability in measurements among several chambers. In collaboration with the Missouri University Research Reactor and three industrial partners, researchers from the Nuclear Energy Institute and NIST have been performing extensive

calibrations of a bone-seeking radiopharmaceutical formulation of ^{166}Ho. This radionuclide is beginning beginning the FDA approval process for use in treating multiple myeloma. The derivation of calibration factors from measurements done on a series of chambers from several manufacturers will allow the producers and eventually the users to accurately measure this radiotherapy agent with dose calibrators in a clinical setting. CONTACT: Brian E. Zimmerman, (301) 975-5191; brian.zimmerman@nist.gov or Jeffrey T. Cessna, (301) 975-5539; jeffrey.cessna@nist.gov or Lisa R. Karam, (301) 975-5561; lisa.karam@nist.gov.

NIST DEVELOPING OPTICAL TECHNOLOGIES FOR ASSESSING STRUCTURES OF CHIRAL MOLECULES

Many organic compounds exist in two identical chemical structures that are mirror images of each other—a characteristic called chirality. In particular, a number of pharmaceuticals are chiral, and while one "enantiomer" may have beneficial effects, the other may be inactive or even produce undesirable effects. Concern over possible or demonstrated negative side effects from one of the enantiomers has accelerated the effort to market single enantiomer or chiral pure drugs.

Despite the demonstrated importance of chiral drugs, the detailed physics underlying the biomolecular interactions responsible for their enantiomeric selectivity often remain obscure. Of fundamental importance is the ability to determine the three-dimensional structure of chiral molecules, and an often-used technique for structural characterization has been to investigate the optical activ-ity of chiral molecules. However, the quantum mechanical models that relate these measurements to molecular structure have not been rigorously tested.

Recently, NIST researchers have successfully characterized the molecular structure of the chiral prototype, binapthol, using high-resolution microwave and ultraviolet molecular-beam spectroscopies. The structure and electronic spectrum of binapthol are being investigated to provide quantitative data to test theories relating optical activity to molecular structure. The researchers recently modified the technique of cavity ringdown spectroscopy to allow sensitive ultraviolet optical-activity measurements. The combination of these spectroscopic techniques will provide a rigorous and unprecedented test of current theories that relate optical activity to molecular structure and, in turn, assist efforts toward understanding the biophysics underlying physiological chiral selectivity.

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A NEW "TWIST" ON NEUTRON REFLECTOMETRY: IMAGING EXCHANGE-SPRING MAGNETS

Scientists of the NIST Center for Neutron Research (NCNR) have developed a new method of using polarized neutron reflectometry (PNR) to extract the structure of buried magnetic spirals in magnetic films. This technique improves upon earlier methods by being particu-larly sensitive to the presence of magnetic twists vis-à-vis structures in which the magnetization direction does not vary appreciably. Tracking the formation and growth of twists may solve a number of puzzles that hamper the development of magnetic thin film devices.

In collaboration with scientists from industry, the technique has been applied to a thin-film exchange-spring magnet. The results confirmed that current theory regarding the behavior of such magnets may be violated. The film consists of the hard ferromagnet $Fe_{55}Pt_{45}$ topped by the soft ferromagnet $Ni_{80}Fe_{20}$. It has been predicted that the combination of soft and hard ferromagnets in close proximity produces a composite which has a strong moment and does not readily demagnetize. As a side effect, when a small external magnetic field is opposed to the magnet, the portion of the soft ferromagnet farthest from the hard ferromagnet may twist into alignment with the field.

Techniques other than PNR typically measure only the average orientation of the magnetic spins and cannot readily distinguish a spiral from a structure in which all the spins are canted with respect to an external field. PNR can extract the depth-dependence of the structure. The new modification of the PNR method greatly enhances the contrast between various structures. First the reflectivity is measured with neutrons glancing off the front surface of the material, and then repeat with neutrons glancing off the back surface. Key features in the data immediately indicate the presence of a spiral, and by studying the film at a number of fields, it is possible to track the development of the spiral. Surprisingly, it is found that the spiral invades the hard ferromagnet even at extremely low fields, in contradiction to current theory.

With this new technique, NIST is now able to better characterize the magnetic properties of thin films, which can improve the capability and reliability of industrial devices for magnetic recording and sensing.

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NIST LEADS EFFORT TO UPDATE AND STANDARDIZE CERTIFICATION PROCEDURES IN THE FEDERAL GOVERNMENT

Under the auspices of the National Information Assurance Partnership (NIAP), NIST hosted an Information Assurance Technology Framework Forum on system certification and accreditation in January 2001. The forum brought together more than 450 government and industry participants worldwide to discuss common technical approaches to IT system certification and accreditation. Presenters included government organizations, insurance and auditing organizations, and producers of IT products and systems. The forum featured state-of-the art tools and techniques for supporting certification activities and provided selected case studies from organizations that have conducted successful certifications.

The process of certification can help provide needed information to accreditation authorities and can affect the ultimate security of IT systems and networks. The certification process provides a well-defined set of activities to manage the security of an IT system throughout its life cycle—from the initial requirements definition phase to the acquisition and procurement phase to the final installation and maintenance phases. With regard to security, the successful certification process helps IT professionals understand what their IT security requirements are, how to obtain the needed IT system and field it successfully, what the IT system actually does when in operation, and how to maintain the security of the installed IT system.

NIST will take a leadership role within the Federal Government in this area by updating its current Federal Information Processing Standard (FIPS) 102, "Guidelines for Computer Security Certification and Accreditation," with inputs from public and private-sector organizations and by the development of more standardized, measurable techniques for assessing the security aspects of IT systems. The objective is to eliminate conflicting and duplicative certification procedures within the government and to obtain consistent application of certification processes across federal agencies. For more information, see http://niap.nist.gov.
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PUBLICATION OF *CHARACTERIZATION AND METROLOGY FOR ULSI TECHNOLOGY: 2000* (AIP CONFERENCE PROCEEDINGS 550)

Characterization and Metrology for ULSI Technology: 2000, containing the proceedings for the June 2000 International Conference on Characterization and Metrology for ULSI Technology, was published in February 2001. The book was compiled by seven editors, led by a NIST scientist.

The book addresses the increasingly difficult challenges faced by the worldwide semiconductor community as it moves into the manufacturing of chips with feature sizes less than 100 nm. Some of the challenges are materials related, such as transistors with high-*k* dielectrics and on-chip interconnects made from copper and low-*k* dielectrics. The magnitude of these challenges demands special attention from those in the metrology and analytical measurements community. New paradigms must be found for working together. Adequate research and development for new metrology concepts are greatly needed.

Characterization and metrology are key enablers for developing semiconductor process technology and in improving manufacturing. Metrology enables tool improvement, ramping in pilot lines and factory start-ups, and improvement of yield in mature factories. It can reduce the cost of manufacturing and the time-to-market for new products through better characterization of process tools and processes. The metrology community must accelerate cooperative research, development, and prototyping in order to meet ITRS (International Technology Roadmap for Semiconductors) timelines.

The book summarizes major issues and gives critical reviews of important measurement techniques crucial to continue the advances in semiconductor technology. It covers major aspects of process technology and most characterization techniques for silicon research, including developments, manufacturing, and diagnostics.

The editors feel that the book of collected papers provides a concise and effective portrayal of industry characterization needs and some of the problems that must be addressed by industry, academia, and government to continue the dramatic progress in semiconductor technology. They hope it also will provide a basis for stimulating practical perspectives and new ideas for research and development. The book, published by the American Institute of Physics, includes about 700 pages of invited and poster papers as well as a keyword searchable CD-Rom.
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MASS METROLOGY TRAINING SEMINAR

Two NIST scientists gave a 2 day seminar on mass measurements at the Measurement Science Conference held in Anaheim, CA. The seminar covered the basics of mass measurements, air buoyancy corrections, cleaning and handling procedures, various measurement procedures, measurement uncertainties, statistical process control, and meas-urement assurance procedures. The seminar was attended by 12 representatives from various sectors of U.S. industry, including aerospace, materials, power, transportation, precision instruments, U.S. Department of Energy laboratories, U.S. Department of Defense laboratories, and domestic and foreign testing laboratories. A number of participants indicated the need for training to meet accreditation requirements, especially regarding uncertainty analysis.

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NIST CONDUCTS WAFER FLATNESS WORKSHOP

Nearly 30 representatives from wafer-manufacturing and instrument-making companies attended a 1 day workshop on wafer flatness metrology at NIST in January 2001. An industry representative set the tone for the meeting with a presentation "Industry Needs to 2014." The clear message from his presentation, was that acceleration ahead of the roadmap leaves wafer suppliers facing specifications for which traceable metrology does not exist. Subsequent presentations reviewed the results of round robins sponsored by the American Society for Testing and Materials (ASTM) and SEMATECH showing large divergence between optical- and capacitance-based methods.

NIST scientists described NIST capabilities and current developments in interferometric measurement methods and also presented an overview of the different types of NIST measurement results that may be reported. After the presentations, a spirited 2 hour debate left no doubt about the industry need for better measurements—and ended with the industry group inviting themselves back for an update on NISTs progress in September.

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NIST HOSTS COMPUTER SECURITY ADVISORY BOARD

In December 2000, in Redmond, WA, NIST hosted the quarterly meeting of the Computer System Security and Privacy Advisory Board. The agenda focused on the development of the 2001 work plan for the board, which identified six specific tasks areas: governance, best practices, the Government Paperwork Elimination Act process, security metrics, privacy, and baseline standards. Work plan proposals for each of the task areas will be developed and considered at the board's March 2001 meeting. Briefings also were presented by the president of the Center for Internet Security, a non-profit cooperative enterprise specializing in reducing risk to e-commerce and business operations in the areas of technical failures and deliberate attacks, and the president of a private company, who discussed the legal and policy implications of the Gramm, Leach, Bliley Act and the Health Insurance Portability and Accountability Act. More information on the board is available at http://csrc.nist.gov/csspab/welcome.html.

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ALLIANCES FORMED IN NANOTRIBOLOGY FOR MAGNETIC DATA STORAGE TECHNOLOGY

As the spacing (distance from the head to the middle of the magnetic layer) in magnetic hard disk storage systems decreases in order to increase the data storage density, head disk collisions become inevitable. Friction at the interface at the time of these collisions often controls the extent of damage to the disk. The measurement of friction and wear (nanotribology) of the head disk interface requires the development of new test procedures.

NIST has signed research agreements with the University of California at San Diego (UCSD) and Data Storage Institute in Singapore, and a cooperative research agreement with a private company. These research alliances provide additional equipment, instrumentation, and expertise to allow NIST to achieve program objectives.

UCSD is providing the expertise and equipment in measuring contact forces at a head disk interface. UCSD also has extensive experience in conducting long-term durability simulation of disk coatings. The Data Storage Institute has commercial scale equipment housed in a

clean room environment for film thickness measurement, micro-buffing, micro-polishing instrumentation of disks. The private company has donated research equipment and support for postdoctoral fellows to explore the fundamentals of how a surface can be protected by a monomolecular layer in the face of increasingly severe impacts.

Working with these partners, NIST researchers have developed the fundamental guidelines of how a monolayer film should be designed to achieve a certain level of shear resistance. Molecular weight, surface mobility, surface bonding characteristics have been shown to be important. Mixed molecular assemblies at a nanometer level have been shown to be feasible by controlling the deposition and surface reaction steps sequentially. This knowledge paves the way for using such monolayers to control surface properties of materials in micromechanical systems, sensors, and actuators.

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NIST HOSTS WORKSHOP ON THERMAL SPRAY PROCESS RELIABILITY

Thermal spray is used to deposit metals and ceramics onto substrates for a wide range of applications. Representatives from industry, universities, and national laboratories took part in a NIST workshop in January 2001, to discuss the role of sensors and diagnostics in improving the reliability of thermal spray processes.

In this workshop, NIST scientists presented their work on process sensors, which had been carried out in response to needs identified in earlier workshops and conferences. The NIST work emphasizes issues of process stability, sensor calibration, and substrate characterization. Many process stability problems arise from long- and short-term variations in the temperature and velocity of particles in the thermal spray plume: sensors developed in the NIST work are revealing the magnitude and origin of some of these variations. Calibration of the non-contact sensors used to measure temperatures of particles and substrates requires knowledge of the material emissivity, and the NIST work showed how reliable emissivity data can eliminate a significant systematic error that results from the frequently-used gray body assumption. In the area of substrate characterization, non-contact sensors for surface topography and temperature are under development.

Speakers from the thermal spray community described some of the factors that make it difficult to obtain reliable and reproducible deposits and some of the sensor needs that would help to overcome these problems. Among the issues cited as important by workshop participants were the need for sensors to be simple, rugged, and reliable for use in industrial environments, the need for more reproducible powder feed stock and thus the need to combine NIST expertise in powder production with thermal spray expertise, the need to sense deposit and substrate characteristics, especially deposit thickness, and the need to correlate improved sensor performance to improved product performance.

The workshop results are being used to refine the direction of the NIST projects and to build working collaborations with the thermal spray industry.

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NEW TECHNIQUE FOR BLENDING POLYMERS YIELDS NOVEL STRUCTURES

Two polymers may be incompatible with each other, yet, when forced together during processing, can produce a material that combines the best features of each. Most engineering plastics are polymer blends. Blending technologies are already in wide use for large parts such as car bumpers, but new applications are emerging for parts that are similar in size to the dispersed polymer droplets.

Using visualization technology to study the polymer blending process, NIST scientists have discovered the formation of novel polymer structures that can occur in such microscale applications. NIST measurements show that, when two incompatible polymer liquids are mechanically blended together, one may deform into very long strings that are extremely stable. This remarkable transformation occurs under special conditions—when the size of a typical polymer droplet is comparable to the size of the part being made, such as ultrathin films and other micron-scale components. When the processing meets these conditions, the droplets spontaneously reorganize into “superstrings.”

Potential microscale applications of super-string components could include conductive plastic wires, ultrathin composite materials and tissue engineering.

A NIST scientist has published a paper on these findings, “String formation in sheared polymer blends: Coalescence, breakup, and finite size effects,” in the Feb. 5, 2001, issue of *Physical Review Letters*.

For more information about this research, contact Migler, (301) 975-4876; kalman.migler@nist.gov.

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NEW TOOL FOR IDENTIFYING VULNERABILITIES UP AND RUNNING

Sometimes, computers just have too much software. Or at least that is the way it seems to many systems administrators who have to stay on top of viruses and other computer security "Achilles heels." Keeping up with the 100 or so new vulnerabilities discovered each month can be an almost overwhelming task, especially since a single software flaw may be known by over 10 different names and no one source provides information on all of them.

However, NIST has developed a way to make keeping up with vulnerabilities much easier. The new extensive ICAT index—available on NIST's World Wide Web site at http://icat.nist.gov—allows people to search for information on vulnerabilities efficiently using a standard naming scheme developed commercially. Users can quickly zero in on the data they need by using pull-down menus that specify product characteristics (such as vendor name and version number) and vulnerability characteristics (such as related exploit type, vulnerability consequence and exposed component type) for more than 2000 software vulnerabilities.

ICAT provides users with summaries of the vulnerabilities and links to public vulnerability databases available on the Internet, which provide detailed information and "patches" to make software more secure. It should prove to be a valuable resource for systems administrators, computer security officers, law enforcement officials, computer security researchers and software developers.

A way to get regular electronic mail updates from the ICAT index via an e-mail service named Cassandra, is available at https://cassandra.cerias.purdue.edu.

For technical information, contact Peter Mell. Comments about ICAT may be sent to icat@nist.gov.
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BALDRIGE CRITERIA CAN HELP ASSESS, IMPROVE . . . AND GO FOR THE GOLD

For a dozen years, the *Baldrige Criteria for Performance Excellence* have helped thousands of U.S. organizations—businesses as well as education and health-care organizations—assess and then improve their performance.

One of the nation's most popular and influential organizational improvement publications, the criteria are tailored for three different audiences: for-profit businesses, education organizations and health-care providers.

The 2001 criteria booklet is easy to use and includes a series of questions covering seven key areas: leadership, strategic planning, customer and market focus, information and analysis, human resource focus, process management and business results.

Over the years, the criteria have been revised and streamlined to focus more sharply on overall strategy-driven performance and results as integral parts of modern management practice. Recognizing the increasing importance of information management, the 2001 criteria include a new item addressing the availability, quality and accessibility of data and the quality of software and hardware.

This year's criteria booklet also includes a new section, which asks an organization to describe its environment; relationships with customers, suppliers and otherpartners; and challenges. This profile is the starting point for both self-assessment and submitting an application. For many organizations, it may be the sole basis for initial action planning.

Single copies of the *Baldrige Criteria for Performance Excellence* are available from NIST by calling (301) 975-2036; faxing a request to (301) 948-3716; sending an e-mail to nqp@nist.gov; or by downloading from www.quality.nist.gov. Additional copies and other material may be ordered for a fee from the American Society for Quality, (800) 248-1946; www.asq.org.
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MARCH SYMPOSIUM SIZES UP THE PAST, FUTURE OF STANDARDS

Thousands upon thousands of standards exist to advance incredibly diverse aims—from ensuring that the threads of fire hoses and hydrants match to enabling computers to connect to networks. In fact, a international professional organization recently ranked the promulgation of standards among the top 10 engineering accomplishments of the last century. But the picture isn't always rosy. These so-called documentary standards sometimes can be bones of fierce contention, triggering market battles, impeding trade and causing diplomatic friction.

In celebration of its 100th birthday, NIST hosted a March 7, 2001, symposium at its Gaithersburg, MD, headquarters, to survey the past, present and future of the occasionally turbulent standards world. Experts from industry, international standards organizations, academe and government weighed the evolving role of standards and the hundreds of organizations that develop them. The focus was on specific economic sectors, such as information technology, transportation and construction.

An important contributor to U.S. and international standardization activities since its creation in 1901, NIST coordinates the Federal Government's standards-related activities with the private sector.

For more information on the NIST Centennial Standards Symposium, visit the NIST Office of Standards Services web page at www.ts.nist.gov/oss; or contact Mary Jo DiBernardo.
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EUROPEAN DIRECTIVE ON MEDICAL TESTING DEMANDS TRACEABILITY

The European Union's *In Vitro* Diagnostics (IVD) Directive, which is expected to be implemented by December 2003, will require the calibration of medical devices for measuring specific substances in IVD samples, such as cholesterol or glucose, to be traceable to a national standard. U.S. manufacturers, which produce more than 60 % of the devices sold in Europe, will need to comply with the directive in order to do business in the EU member countries.

A recent workshop at NIST marked the first time that stakeholders worldwide gathered to discuss the issues raised by the impending regulation and make recommendations for dealing with it. Traceability to a national standard will help assure that an individual test achieves the same results for the IVD sample, no matter which manufacturer's device is used. Today, many diagnostic tests have to be redone because of inconsistent results.

As a follow-up to the "Workshop on Measurement Traceability for Clinical Laboratory Testing and *In Vitro* Diagnostic Test Systems," NIST is developing a database of currently available reference materials and methods, which will be accessible on the NIST World Wide Web site within the next few months. This information will help the IVD industry by serving as a benchmark for developing individual diagnostic tests.

For more information about the workshop and NIST's IVD testing activities, contact William Koch, (301) 975-8301, william.koch@nist.gov.
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NIST ASSESSES REDUCED IGNITION PROPENSITY CIGARETTE FOR FTC

In May 2000, the Federal Trade Commission (FTC) requested that NIST conduct tests to determine whether a cigarette being test marketed at the time and made with a slower burning paper would reduce the risk, if dropped or discarded, of starting a fire. This "reduced ignition propensity" technology has been more commonly, but incorrectly, called "fire-safe" in the past. While NIST does not routinely perform product tests, it agreed to do so in this case, recognizing the important role of the FTC in assuring the public of the veracity of product claims and the high potential for reduced ignition propensity cigarettes to reduce fire deaths and injuries.

NIST staff purchased conventional and modified cigarettes from the market and measured the relative ignition propensities of the two cigarette types using laboratory procedures developed by NIST under the Fire Safe Cigarette Act of 1990 and now being considered as an industry standard by the American Society of Testing and Materials. Analysis of the test data, acquired between June 2000 and September 2000, shows that the modified cigarette has a lower relative ignition propensity than its conventional version.

A copy of the report, *Relative Ignition Propensity of Test Market Cigarettes* (NIST Technical Note 1436), is available on the World Wide Web at www.nist.gov/public_affairs/cigarette.htm. Questions and answers about NIST's work with reduced ignition propensity cigarettes may be found at the same address. For technical information, contact Richard Gann, (301) 975-6866; richard.gann@nist.gov.
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VIRTUAL LAB CONSORTIUM TO TEST CONCRETE AND CEMENT FORMULAS

Construction engineers routinely wait 28 days after a concrete building mixture has been made to test its comprehensive strength. Such stringent quality controls produce results that make cement and concrete a favorite choice of builders. However, these tests can be costly. In addition to construction delays caused by the long waiting period, companies also pay for the raw materials, materials storage and curing space, employees to prepare the material and test it, and the disposal of the test batch. Some firms spend more than $500 000 yearly on these materials quality tests.

NIST researchers and industry partners intend to change that situation. They recently launched the Virtual Cement and Concrete Testing Laboratory (VCCTL) Consortium to develop a computer-based or "virtual" laboratory that could quickly evaluate cement and concrete mixtures. VCCTL consortium members will collect data on relevant raw materials and concrete mixtures, incorporate the information into computer models, and then use the computer simulation of different cement-based mixtures for rapid quality evaluations. Once material characteristics of different concrete and cement mixtures are known, computer

models could reveal their "28 day strengths," as well as other properties of interest, within hours.

Six companies have joined the VCCTL consortium so far. Further private-sector membership is invited. Version 1.0 of the VCCTL software is available at http://vcctl.cbt.nist.gov.

For more information, contact Dale P. Bentz, (301) 975-5865; dale.bentz@nist.gov, or go to http://www.bfrl.nist.gov/862/vcctl on the World Wide Web. Media Contact: John Blair (301) 975-4261; john.blair @nist.gov.

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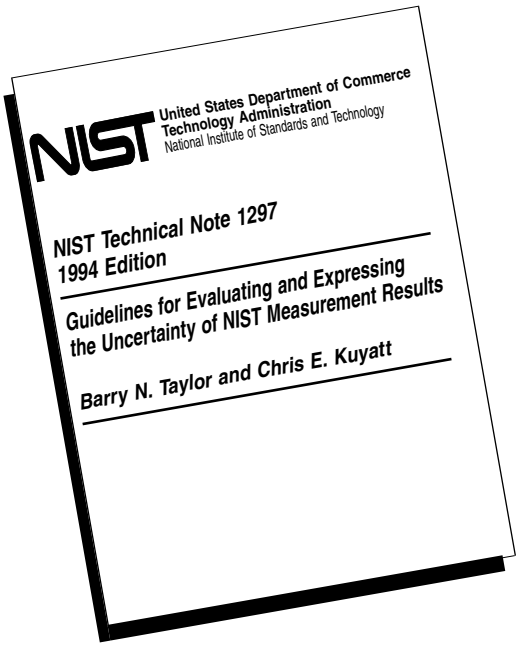

Uncertain about expressing measurement uncertainty? Do you need to know how NIST states the uncertainty of its measurement results and how you can implement their internationally accepted method in your own laboratory? Then you need the newly available 1994 edition of the National Institute of Standards and Technology Technical Note 1297, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results.*

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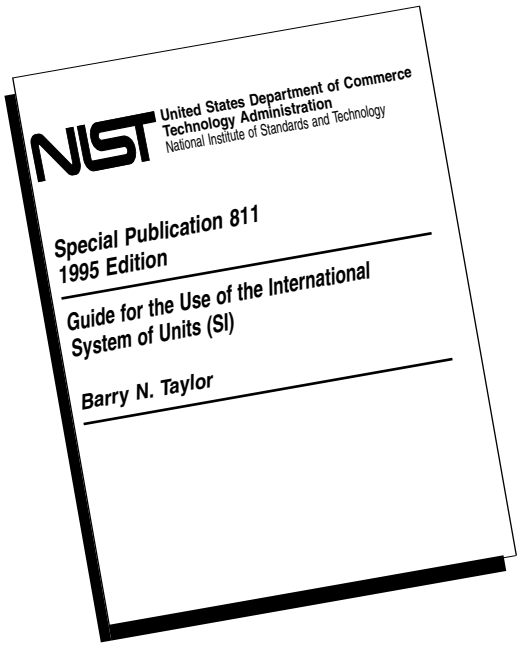
The 1994 edition of TN 1297 includes a new appendix—Appendix D—which clarifies and gives additional guidance on a number of topics related to measurement uncertainty, including the use of certain terms such as accuracy and precision. Very minor word changes have also been made in a few portions of the text of the 1993 edition in order to recognize the official publication in October 1993 by the International Organization for Standardization (ISO) of the *Guide to the Expression of Uncertainty in Measurement* on which TN 1297 is based. However, the NIST policy on measurement uncertainty, Statements of Uncertainty Associated with Measurement Results, which is reproduced as Appendix C of TN 1297, is unchanged.

It is expected that the 1994 edition of TN 1297 will be even more useful than its immediate predecessor, the 1993 edition, of which 10 000 copies were distributed worldwide.

Those United States readers who wish to delve into the subject of measurement uncertainty in greater depth may purchase a copy of the 100-page ISO *Guide* from the Sales Department of the American National Standards Institute (ANSI), 105-111 South State Street, Hackensack, NJ 07601. Copies may also be purchased from the ISO Central Secretariat, 1 rue de Varembé, Case postale 56, CH-1211 Genève 20, Switzerland.

Single copies of the 20-page TN 1297 may be obtained from the NIST Calibration Program, 100 Bureau Dr., Building 820, Room 236, Stop 2330, Gaithersburg, MD 20899-2330, telephone: 301-975-2002, fax: 301-869-3548.

The International System of Units (SI)
The Modern Metric System



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The 1995 edition of the National Institute of Standards and Technology Special Publication 811, *Guide for the Use of the International System of Units (SI)*, by Barry N. Taylor, is now available.

The 1995 edition of SP 811 corrects a number of misprints in the 1991 edition, incorporates a significant amount of additional material intended to answer frequently asked questions concerning the SI and SI usage, and updates the bibliography. The added material includes a check list for reviewing the consistency of written documents with the SI. Some changes in format have also been made in an attempt to improve the ease of use of SP 811.

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- Conversion factors for converting values of quantities expressed in units that are mainly unacceptable for use with the SI to values expressed mainly in units of the SI.
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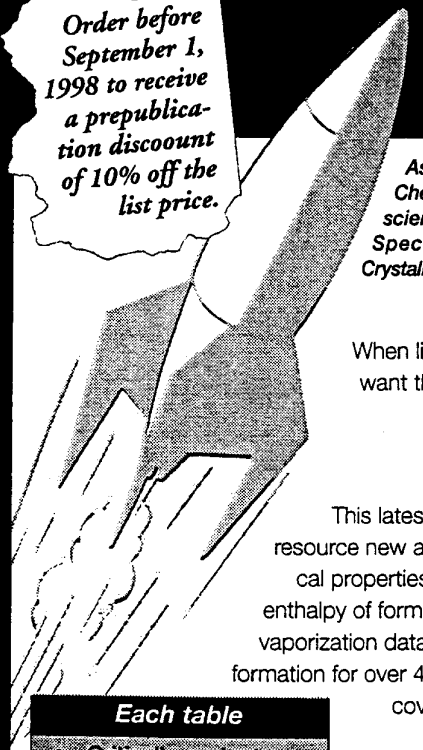

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